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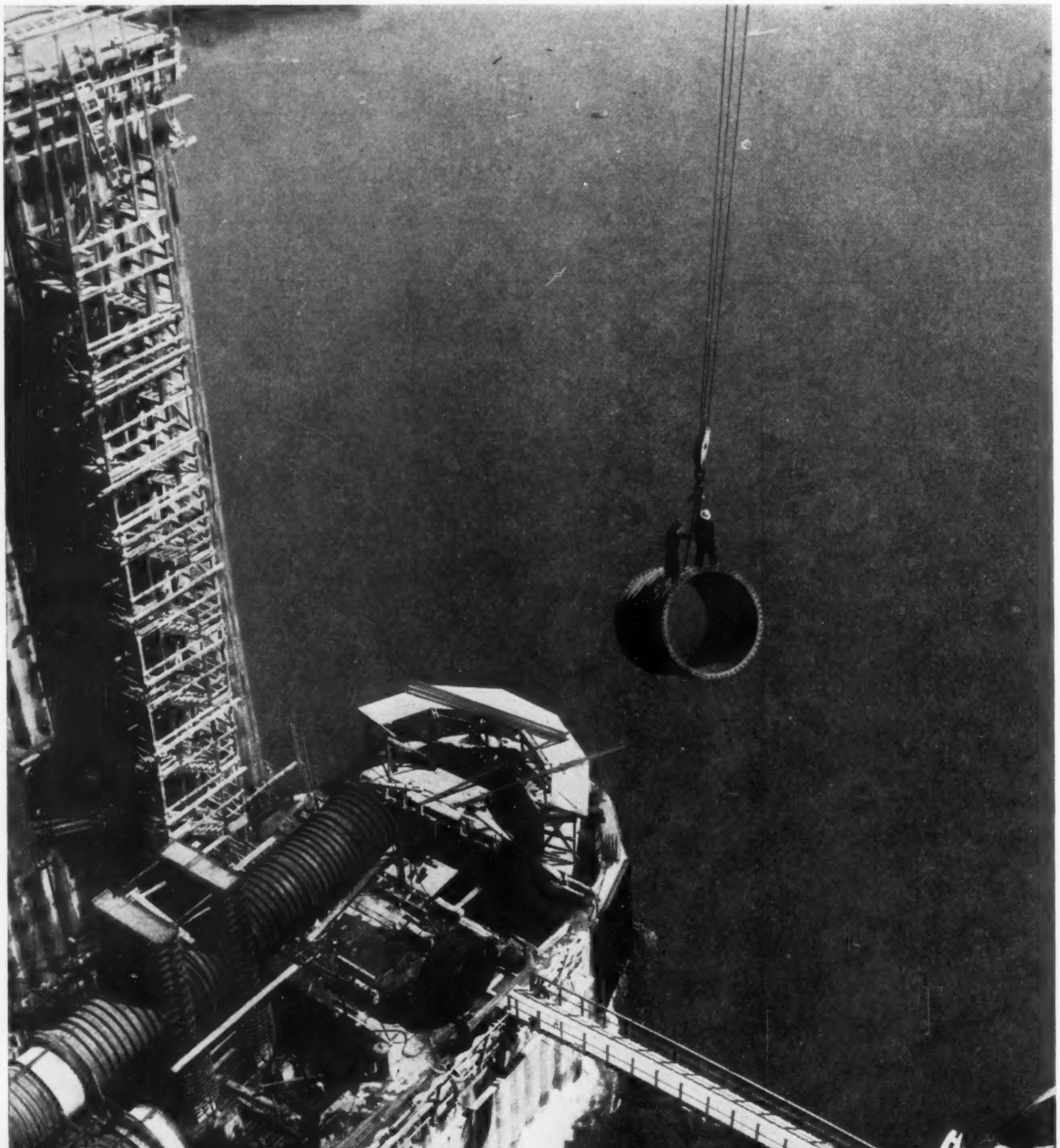

Placing a Section of $8^1/_2$-Ft Outlet Lining in Grand Coulee Dam

(See pages 651–660 for description of Grand Coulee project.)

Volume 62
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MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

National Preparedness

As THIS is being written, increasing violence of the raids on Great Britain indicate that the supreme test of the ability of the British to survive a modern military attack is on. That America may avoid the consequences of delay and underestimation of the serious situation her people face, the Administration, all government agencies, and a considerable number of citizens are working night and day in the interests of national defense and in the aid of freedom's cause. Perhaps by the time these sentences are read the invasion of Britain will be going forward with all the fierce savagery that must attend such a desperate venture. Perhaps the outcome will be more accurately predictable then than it is today. But whatever the outcome is, the necessity for America to defend herself will be more intense, and efforts on behalf of that defense will be spreading. We shall be closer then than we are today to the realization of the sacrifices the times will demand of us. A greater number of us will have decided to put forth the effort to meet those sacrifices. Our objective, then as now, must be individual and national preparedness.

What the mechanical engineer will be called upon to do in the national defense will depend upon the circumstances in which he finds himself. Many are already engaged. Many more are awaiting the call to service. Last month on these pages the A.S.M.E. Committee on National Defense presented a statement of the Society's efforts and a plea for comprehension of the importance of the time element. This statement also outlined briefly the work of the National Defense Advisory Commission on which several A.S.M.E. members are serving. The situation, it said, was in good hands, as it still is, with the handicap of delay occasioned by failure of the Congress to come to a decision on the amortization and tax bills. It advised A.S.M.E. members who are anxious to take part in the national industrial program to stay away from Washington in the interests of orderly procedure. By this time it must be generally known that 46 field procurement offices of the War Department and 27 field purchasing offices of the Navy Department have been set up in convenient locations all over the nation. In addition to these are the arsenals and navy yards. Questions and offers of assistance should be directed to the nearest of these offices, not to Washington.

Hundreds of plants are already at work on orders for the 70,000 articles needed by a modern army and navy. Others are negotiating contracts, and still others are seeking them. Until the signal is given for a plant to proceed with an order, national interest demands the intensive preparation of all plants and individuals for whatever the emergency may demand of them. Be prepared. Put the plant and the organization in order. Find out what you and your plant can do best, and get ready to do it if the opportunity presents itself. If sacrifices have to be made, make them when the need arises. For if sacrifices are not to be made in vain, they must be made in time. And time is tragically important.

Much as this country may deplore the ends toward which Germany has been exerting her major efforts during the last five years, it cannot overlook the thoroughness with which preparations were made. Common sense demands a similar thoroughness in our preparation for defense. The intelligence of the American engineer in developing ideas and adapting them to useful purposes is well known. The times demand thinking of the daily task in terms of national defense. Materials, machines, and techniques developed for one purpose are invariably applicable sooner or later to other purposes. Such is the history of technological progress. Great and essential industries have grown out of scientific novelties. New businesses have been founded on accidents and the fertility of vision and imagination. How can your product and your skill be adapted to the national defense? You don't have to have an extensive research laboratory and a staff of research workers. Perhaps you have a mechanic whose skill has developed methods that would save time and money in producing some items of national defense. Perhaps your requirements for sorely needed strategic and critical materials can be reduced by the substitution of a more abundant material. Discover these possibilities by intelligent concentration on the nation's needs.

The ability and capacity of the American people to produce are second to none. Because of them this country has raised its material standards of living above those of any other nation. Our people have more things to enjoy than any other. These things are produced with less expenditure of hours of work and human physical effort in this country than in any other. Once our minds are made up that we are going to produce for the national defense we shall do so superabundantly. But shall we do it in time?

Common danger should draw us together in a common effort in which selfish and personal differences are submerged for the common welfare. Unity and cooperation are necessary if we are to make effective use of our ability and capacity to produce for the national defense. The dictator nations rely on imposed authority, but they

achieve national unity. Democracies rely more largely on voluntary contribution. Voluntary contribution to the common welfare is based on individual initiative coordinated by leaders who enjoy the confidence of the people and who are subject to the collective will. The only compulsion we face arises from without our own borders. Our responsibilities are severe and personal because we are the state and not creatures of the state. Our first orders are given by ourselves, not by others. It is the harder way because the preparation of the nation is based on the preparation of the individual.

We cannot underestimate the state of preparedness that we must achieve as quickly as possible. A free people does not need to wait for orders from a dictator. It mobilizes the forces of the individual and holds them responsive to the common will expressed through delegated authority residing in its representative rulers. The method may appear to be less efficient than that which treats citizens as slaves, but in spite of this handicap history has shown that it produces the more virile and progressive Society. The decline of ancient Rome began with the undermining of citizen control by the subtle methods of Augustus Caesar to whom one liberty after another was thoughtlessly surrendered. A people that does not hold its liberties deprives the individual of self-assurance, self-reliance, and self-respect. It deserves its ultimate condition of slavery and poverty. If the individual remains self-assured, self-reliant, and self-respecting, the nation will remain so.

The times demand reconsideration of these truths, and rededication to the way of life they indicate. The choice lies with the individual. In the turmoil of world change in which America is caught up, maintenance of its way of life and the evolution of that way into more satisfying forms must be a task for the individual if it is to be the policy of the nation. The engineer holds a strategic position in the preservation of liberty. No matter how humble his station, it is his obligation not only to prepare himself for sacrifice and intelligent effort, but also to assist in preparing the enterprise with which he is associated. The way to begin is with ourselves, our families, our plants, and businesses, and to work harmoniously with others in preparing the nation. This is real national preparedness.

Educational Program for Defense

COMMON sense dictates that if the engineering colleges are to render effective service in the cause of national defense, they should conduct whatever special educational program may be required of them primarily on the college and not the trade-school level. This principle has been guiding A. A. Potter, past-president of The American Society of Mechanical Engineers, in the preliminary steps in plans to coordinate the programs of engineering educational institutions and the needs of national-defense agencies in his capacity as consultant in engineering education to the U. S. Office of Education, Washington, J. W. Studebaker, commissioner.

Studies made by Dean Potter have uncovered many engineering services for which trained men are urgently needed. For each of these services Dean Potter has established the specific need in kind of service and number of men (meteorologists, for example), the educational preparation necessary as a background for the trainee, the duration of a proposed course of training, the educational institutions which possess the facilities for carrying on the proposed courses, and the number of men each institution can handle. An appropriation to reimburse the colleges who may engage in the program is being requested by the Office of Education. Dean Potter's wise leadership is developing an intelligent and properly coordinated program.

Bound Transactions Now $4

MANY members of The American Society of Mechanical Engineers still regret the change in Transactions policy made about 1927 when the annual bound volume, formerly sent free to all members, was abandoned in favor of periodical issues which made possible, without extra cost, publication of a greater number of technical papers. Although the change was made in the "flush twenties," it is probable that the Transactions could not have been carried on during the last ten years with anything like the present amount of material if the free bound volume had been retained. For example the cost for binding alone in 1925 was more than half as great as the entire publication cost of the Transactions and the *Journal of Applied Mechanics* in 1939.

In order to provide bound copies of the Transactions to those who wished to have them for reference, several plans were adopted by the Council. By paying $10 per year a member might receive a copy of the Transactions of the year in bound form. He could also arrange to return his monthly issues to headquarters and have them bound at a cost of $3. Provided he so authorized the Society, a member could elect not to receive his monthly issues but have them mailed to him in bound form at the end of the year at an extra cost for binding of $2.25.

In reviewing these prices in an endeavor to improve service to members, the Committee on Publications decided to recommend to the Council that the price of the bound Transactions to members who also receive the monthly issues be reduced from $10 to $4 per year, and that the price of the bound volume to those who do not receive the monthly issue be set at $2.

The annual bound volume contains all the technical papers contributed to the Transactions by the professional divisions, technical committees, and local sections, including the *Journal of Applied Mechanics*, as well as the Society Record, which consists of memorial notices to deceased members, complete list of Society committee personnel, and indexes to MECHANICAL ENGINEERING, Transactions, *Journal of Applied Mechanics*, unpublished papers on file at headquarters, and other publications, such as codes and standards. Copies of the A.S.M.E. Transactions are deposited every year in bound form in about 240 libraries in the United States and 100 in other parts of the world.

WORK NEVER STOPS ON THE GRAND COULEE

THE GRAND COULEE DAM

And The Columbia Basin Reclamation Project[1]

By S. E. HUTTON

BUREAU OF RECLAMATION, COULEE DAM, WASH.

THE Grand Coulee Dam is the most spectacular, the best known, and the most important engineering feature of both the Columbia Basin Reclamation Project and the program for developing the Columbia River, the greatest power stream in North America. It is the greatest of all dams in volume—three times the size of the next largest man-made structure in the world; but, more important than that, it is the greatest of all dams in economic value, for it will create employment opportunities and better living conditions for hundreds of thousands of people.

Specifically, the Grand Coulee Dam will create farm homes and towns on a million-two-hundred-thousand-acre tract of rich soil, in an excellent climate, within the next twenty-five to fifty years; it will capture, annually, billions of kilowatthours of energy now running to waste; it will increase the firm-power capacities of present and future downstream power plants; and it will conserve wasting natural resources.

The economic significance of the dam is not limited to the Pacific Northwest, for, in developing that section of the country, it will enlarge important markets for the products of eastern factories, and for the products of Middle West farms. The Far West cannot now and never can feed its own population. It is valuable to the country as a whole because it is the source of needed goods and strategic materials, which it exchanges for eastern manufactured goods and Middle West foodstuffs.

ECONOMIC FEATURES OF THE FAR WEST

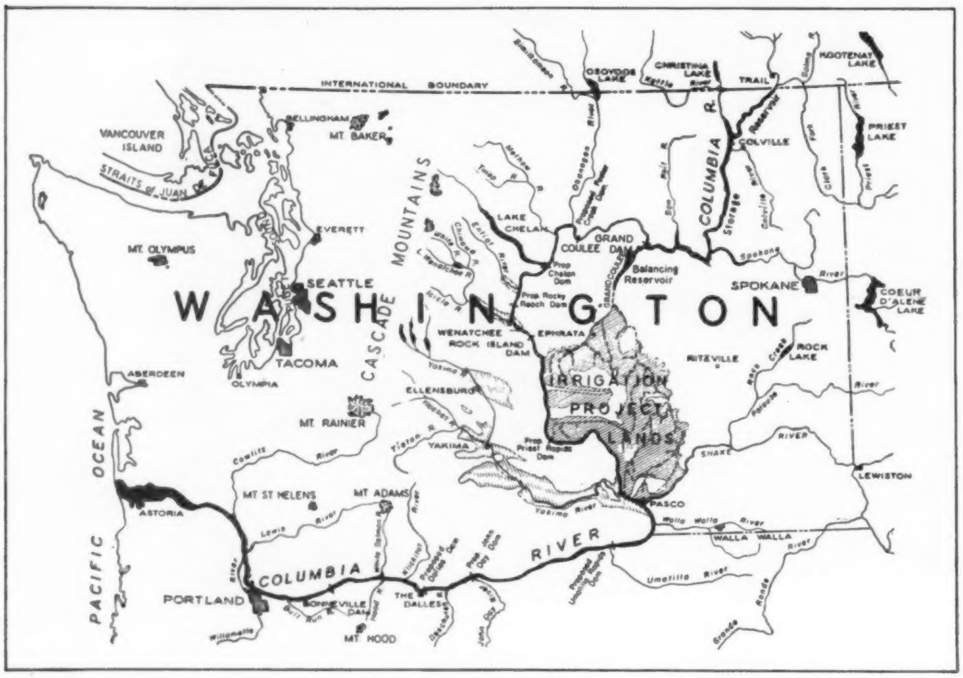
The significance of the dam can be realized only in the light of some knowledge of the peculiarities of the Columbia River, and of some of the geological, geographical, climatic, and economic features of the western third of the United States.

The eleven western states cover more than one third of the area of the nation. They are a country of mountains, forests, and desert land, more than half of which is held by the government in parks and reserves and otherwise. Except in a narrow strip along the coasts of Washington, Oregon, and northern California, the annual rainfall is 20 in. or less. In some such localities, precipitation is sufficient for dry farming, but it is not sufficient anywhere for intensive agriculture.

Of the 700,000,000 acres of land west of the 100th meridian,

[1] The purpose of this paper is to give to those who visit the Grand Coulee Dam, while in attendance at the 1940 Fall Meeting at Spokane, Wash., and to those who hear or read the special papers dealing with specific details or phases of the project, which are to be presented at this meeting, a general knowledge of the economic bases and the major technical features of the project. These technical papers are: "Cooling the Concrete at Grand Coulee Dam," by Clarence Rawhauser; "Design and Technical Aspects of a Frozen Earth Dam at Grand Coulee Dam," by Lloyd V. Froage; "Turbines for Grand Coulee Dam," by J. J. Burnard; "Testing of Pumps for Grand Coulee Dam," by R. T. Knapp; "Control Gates at Grand Coulee Dam," by P. A. Kinzie; "Penstocks for the Grand Coulee Dam," by P. J. Bier; and "Transportation and Handling Equipment for the Placing of Concrete at Coulee Dam," by Ray Fullerton.

For presentation at the Fall Meeting, Spokane, Wash., Sept. 3–6, 1940, of The American Society of Mechanical Engineers. Slightly abridged.



MAP OF STATE OF WASHINGTON AND THE COLUMBIA RIVER BASIN SHOWING SITE OF GRAND COULEE DAM, THE BALANCING RESERVOIR, AND THE IRRIGATION-PROJECT LANDS

only about 30,000,000 can be irrigated economically. Of that 30,000,000 acres, 20,000,000 are now under irrigation, chiefly as the result of private enterprise, without federal aid. With one tenth of the population and only one twentieth of its farm land, the western third of the country must always, like rugged New England and several densely populated industrial states, be dependent largely on the Middle West for foodstuffs.

DEVELOPMENT OF THE UPPER COLUMBIA RIVER

In its plan for the ultimate development of the Columbia River, the Engineers Corps proposes ten dams along the 750-mile course of the Columbia within the United States, the uppermost of which is the Grand Coulee Dam. It will develop 27 per cent of the 1290-ft fall of the river between the Canadian border and tidewater below the Bonneville Dam, and it will have a generating capacity of nearly two million kilowatts.

By means of storage reservoir of ten million acre-feet capacity created by the dam, it will be possible, by regulation of the river flow, to double the firm-power output of other plants above the mouth of the Snake River, and to add 50 per cent to the firm-power capacity of lower plants, including that at Bonneville. Seasonal power, generated by the flood waters of summer, will pump water for the irrigating of the largest tract of undeveloped irrigable land in the country.

ESSENTIAL FEATURES OF THE COLUMBIA BASIN PROJECT

The essential features of the Columbia Basin Reclamation Project are the Grand Coulee Dam; a storage reservoir of ten million acre-feet capacity above it, extending up the Columbia River canyon to the Canadian border; a pumping plant at the dam; a 27-mile balancing reservoir, formed in the Upper Grand Coulee, 600 ft above the river bed, by two earth-fill dams; and a system of distributing canals, drops, wasteways, and auxiliary power and pumping plants, to be built as the project develops.

The characteristics of the Columbia River, and of the country through which it flows, account for this combination.

The river drains an area of 259,000 square miles, including almost the entire state of Idaho, the greater part of Washington and Oregon, and parts of Montana, Wyoming, Utah, Nevada, and British Columbia. Notwithstanding that the area drained by it is arid or semiarid, except in mountainous districts, the Columbia is exceeded in annual runoff by the Mississippi alone, of the rivers of North America, and is the greatest power stream on this continent.

Above the Coulee Dam, the drainage basin of the Columbia and its tributaries covers an area of 74,100 square miles, of which 39,000 are in Canada. Of the three most important contributors, the Clark Fork, rising near Butte, and draining western Montana, releases its flood waters earliest. Then the Kootenai and Columbia main stem follow, in order, causing the flow at the dam to reach a maximum in June or July. It is high throughout the summer; and all water for irrigation purposes, and all power for pumping irrigating water, will be furnished by surplus summer flood water, originating in extensive ice fields in the Selkirks and Canadian Rockies. This unique feature of the upper Columbia will make it a valuable complement to other Northwest power streams which are low in summer.

The average recorded daily flow at the dam site since 1913 has varied from a minimum of 17,000 cfs to a maximum of 492,000 cfs, and is believed to have reached 725,000 cfs in 1894. The mean flow is about 110,000 cfs, and the mean annual runoff is about 80,000,000 acre-feet.

ENERGY AVAILABLE AT THE GRAND COULEE DAM

With the Grand Coulee Dam of such height as to back stored water up to the Canadian border, 151 miles away, the head available for power at the dam varies from 256 to 358 ft, with a weighted average of 333 ft. The energy economically available annually will be 12,510,000,000 kwhr. Billions of kilowatt-hours will go to waste in the summer flood periods.

It is estimated that 1,970,000,000 kwhr of off-peak energy will be used ultimately in pumping water for irrigation, and that 85,000,000 kwhr will be used in the plant, on the dam, and in the associated towns. There will be for sale annually, when the plant is completed, 10,455,000,000 kwhr, firm energy not falling below 8,100,000,000 in years of estimated lowest runoff.

The planned installation includes 18 generating units rated 108,000 kva each, and three units for local service, each rated 10,000 kw at 80 per cent power factor. There are now under construction by the Westinghouse Electric & Manufacturing Company three large generators, and by the Newport News Shipbuilding and Drydock Company three 150,000-hp turbines to drive them. The first of the three units is to be in operation in August, 1941, and the third in February, 1942. Two 14,000-hp turbines, built by the Pelton Water Wheel Company, were installed during the spring and summer of 1940, to drive two Westinghouse 12,500-kva generators.

POWERHOUSES

Power-plant equipment will be divided between two powerhouses, one on each side of the central spillway section, and parallel with the dam. Each powerhouse is to contain nine large generating units, and the left powerhouse will accommodate, also, the three station-service units. Only the left powerhouse has been built, but foundations and penstocks for the right powerhouse have been installed.

The large units, spaced 65 ft, will occupy the generator rooms, 75 ft wide by 589 ft long. At the abutment end of each powerhouse is a service bay, and adjoining it is a control building. Over-all, the left powerhouse is 764 ft 8 in. long and 84 ft wide. From the floors of the draft tubes to the parapet of the control building, the height is 200 ft.

LARGE TURBINES

The Francis reaction-type main turbines are rated 150,000 hp at 330-ft head, and 90,000 hp at 263 ft, at a speed of 120 rpm. The water entrance diameter is 15 ft, and the scroll case, normal to the entrance, is 51 ft $5^1/_2$ in. wide. Runners are 16 ft 5 in. in diameter, with an entrance height of $34^3/_8$ in. An efficiency of 90 per cent is guaranteed at outputs of 120,000 to 130,000 hp.

Shafts are 44 in. in diameter, and 74 ft long, with 6-in. axial holes for inspection after fabrication and to admit air to possible vacuum spaces in the turbines, to minimize vibration and cavitation. Each shaft runs in three guide bearings, one at the turbine, one below the generator rotor, and one above the generator, the latter inclosed with the thrust bearing in a common oil reservoir. Bearings are of the adjustable segmental-shoe type; those at the generator self-lubricating, that at the turbine pressure-lubricated. Each thrust has approximately 5250 sq in. of bearing surface, giving a unit pressure of 400 psi with a load of 1300 tons. Upper guide-bearing areas are each 600 sq in., and the turbine guide-bearing area is 3450 sq in. Water will pass through a fully loaded main turbine at the rate of about 140 tons per second.

PENSTOCKS AND COASTER GATES

Penstocks for all of the 18 large turbines and the three station-service units have been installed. They are buried in reinforced concrete, in tunnels left for them in the base of the dam. The large penstocks are closed at their upper ends with hemispherical welded plate-steel bulkheads, to be removed as turbines are installed. Temporary timber bulkheads on the upstream face of the dam closed two of the small penstocks while the gate valves and turbines were being installed. The third is closed by a steel bulkhead at its lower end.

The large penstocks are 18 ft in diameter, and vary in thickness from $^3/_4$ in. at the upper ends to $1^1/_2$ in. at their outlets. They were made up in 20-ft lengths at the dam, from plates shaped and planed in Chicago. Shop joints in plate $1^1/_{16}$ in. and thinner were welded on automatic machines with a single pass. Heavier plates, and the construction joints between the 20-ft sections, were hand-welded, the weld metal of each pass being peened to relieve shrinkage stresses. All welds were X-rayed. Unlined concrete transition sections connect the gate openings, 15 ft wide and 29 ft $7^3/_4$ in. high, in the upstream face of the dam, and the 18-ft penstock linings. Forty-five-foot curved transition sections of steel pipe are used to connect the 18-ft penstock linings with the 15-ft entrances to the turbine scroll cases.

Entrances to penstocks can be closed by means of heavy hydraulically operated structural- and plate-steel coaster gates on the upstream face of the dam. Endless roller trains along the sides of the gates travel on metal guides. Grooved bronze bars, mounted on diaphragms in front of chambers in the gates, and under control of valves operated by gate overtravel, make a watertight connection between the gate and the dam face, when a gate is in its closed position. Draining the diaphragm chamber retracts the seal before a gate is raised.

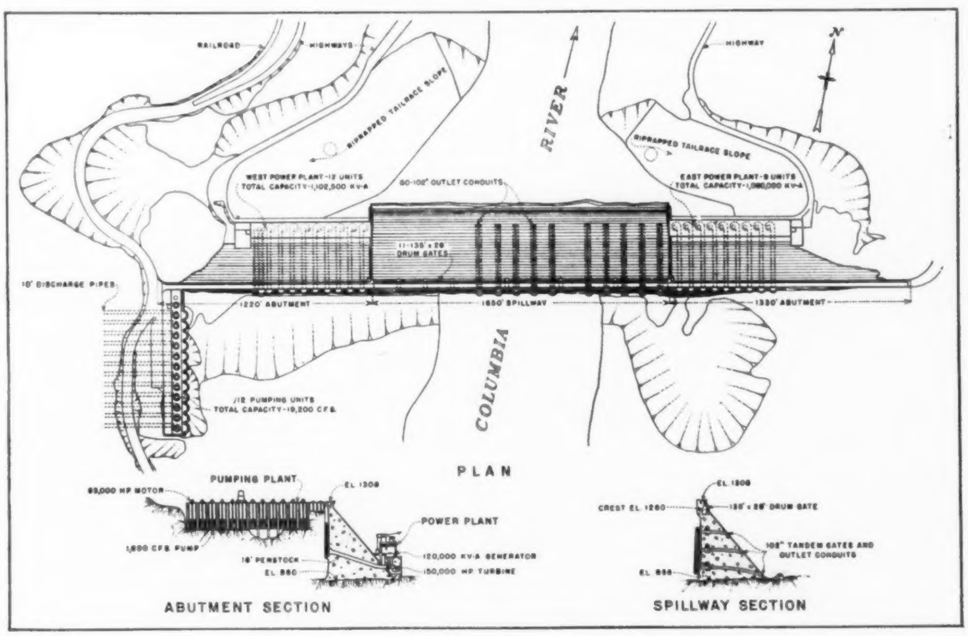
There are no butterfly or balanced valves in the large penstocks. Gate valves are provided in the 6-ft station-service penstocks. Bulkheads can be placed over coaster gates and over entrances to station-service penstocks by 150-ton cranes traveling on top of the dam. Trash racks prevent floating debris from entering penstocks. An air-bubbling system will prevent the formation of ice on the trash racks.

LARGE GENERATORS AND TRANSFORMERS

The large 60-cycle, 3-phase, star-connected generators will run at 120 rpm and generate 13,800 volts. Rotors will be about 31 ft in diameter, and will have flywheel effects of 150,000,000 lb at a one-foot radius. On the lower side of each will be a brake ring. Air-operated brake cylinders will bring the rotors to a standstill from half normal speed in $7^1/_2$ min. The brake cylinders can be made to serve as hydraulic jacks to lift the rotors sufficiently to permit the removal or adjustment of thrust-bearing parts. The estimated shipping weight of each generator is 2,367,000 lb. Over-all, the assembled generators will be 45 ft in diameter and 22 ft high, above the operating floor.

Guaranteed generator efficiencies range from 93.4 per cent at quarter capacity to 97.4 per cent at full load.

A bank of three 36,000-kva, 13,800 to 132,800/230,000-Y-volt



GRAND COULEE DAM AND APPURTENANT WORKS

transformers will be connected to each generator through circuit breakers. The transformers are to be out-door type, oil-immersed, water-cooled, gas-filled, designed for delta-star connection, with high-voltage neutrals grounded. They will be located between the powerhouses and the dam. Provisions will be made for connecting each of the first six generators with either a bank of three transformers and outgoing lines or two 65,000-hp synchronous motors in the pumping plant behind the dam.

GROUNDING SYSTEM

Four ground mats of copper cable have been provided, two on each side of the river There is one beneath the foundation of each powerhouse, and one in the river bed, under the riprap of each tail bay. The mats consist of 200,000 and 500,000 circular-mil bare copper cables, and are connected by bare cables in the concrete with 750,000-circular-mil insulated ground buses in the powerhouses. Ground leads extend also to the powerhouse roof, for connection with ground leads from overhead equipment.

STATION-SERVICE UNITS

Three 10,000-kw generating sets, two of which are included in the initial power-plant installation, will furnish energy for power, heat, and light in the powerhouses, dam, and pumping plant, and for municipal and domestic use in the government town. The generators, operating at 60-cycle, 3-phase, 6900 volts, 400 rpm, are rated 12,500 kva. Turbines are rated at 14,000 hp at 330-ft head, with a guaranteed efficiency of 90 per cent at 11,500 hp under 330-ft head. Their 14-in. shafts are provided with 3-in. axial holes for inspection and air admission. Runners are $58^1/_2$ in. in diameter, with an entrance height of $11^3/_4$ in. The maximum diameter of the cast-steel scroll case is 18 ft $5^3/_4$ in., and the water entrance is 5 ft 4 in.

CRANES IN THE POWERHOUSE AND ON THE DAM

Two traveling cranes, with a span of 72 ft 8 in. have been installed in the left powerhouse for handling generator rotors and other heavy loads. Each crane carries two trolleys of 175 tons capacity and two 30-ton auxiliary hoists. Through a heavy H-shaped equalizer, the two cranes can lift a 700-ton load.

In the station-service generator room, a 50-ton single-trolley bridge crane, which has a 12-ton auxiliary hoist, has been provided.

A 14-ton single-leg gantry crane, traveling along a balcony on the downstream side of the powerhouse, will handle draft-tube bulkhead gates; and a 150-ton gantry, with overhanging hoist for handling coaster gates and a 25-ton movable trolley for handling bulkheads, will travel along the roadway on top of the dam.

FEATURES OF THE DAM

The dam is of the gravity type, extending straight across the river canyon. At the base, it is 500 ft wide and 3000 ft long; and at the crest 30 ft wide and 4300 ft long. From lowest bedrock to the crown of the 30-ft roadway on top of the dam, the height is 550 ft. The volume will exceed 10,500,000 cu yards.

On each side of a 1650-ft centrally located spillway section there is a powerhouse and abutment section. At the top of the spillway, there will be 11 drum gates, each 28 ft high and 135 ft long, and each spanned by a reinforced-concrete arch bridge. At the base of the spillway, a "bucket" or trough, 90 ft wide and 30 ft deep, with its downstream edge, at different seasons, 30 to 75 ft below the tail-water surface, dissipates the energy of the falling water, and prevents serious downstream erosion.

River regulation will be accomplished by means of the eleven spillway drum gates and sixty $8^1/_2$-ft outlet conduits, 20 at low-water level, and 20 at elevations 100 ft and 200 ft above low-water level.

In each outlet conduit, near the upstream face of the dam, are two gate valves. In each of the lower conduits a plain sliding-gate stop valve and a "paradox" operating valve have been installed. The latter embodies a wedge, supported on rollers, which moves the valve leaf horizontally away from its seat before it rises on other rollers to its open position. In each of the upper conduits, two "ring seal" gates, a later development, have been used. Their leaves move on roller trains running on guides in the valve bodies. The bronze seal rings on the leaves, mounted on rubber, are moved horizontally to make or break contact with seat rings in the valve bodies, and so prevent sliding and possible damage to valve seats.

The maximum anticipated drawdown (for 5,200,000 acre-feet) will be 80 ft. The greater part of the river regulation will be accomplished by means of the drum gates.

Within the dam is a system of galleries totaling $8^1/_2$ miles in length. In addition to a gallery which follows the irregular profile of the bedrock, level galleries extend from wall to wall of the canyon at vertical intervals of 50 ft, from elevation 900 to elevation 1250. Numerous adits extend from main galleries toward the downstream face of the dam. Galleries are used for inspection, cooling, grouting, and to some extent in operations.

PRINCIPAL CONSTRUCTION CONTRACTS

Work on the project began late in the summer of 1933, when, in order to provide employment quickly, a contract for the removal of two million yards of overburden from the dam site was let to David H. Ryan. A slide in the fall of 1934 added a million yards to the Ryan job. Power shovels and heavy trucks moved the greater part of the material, but tractor-drawn scrapers were also used.

Although the purpose was always to develop a combined irrigation and power project, which would require a high dam of the type and size now under construction, it was proposed to build first a low dam, useful only for the generation of power, and to build over it later the high dam. A contract for a low dam and powerhouse was let July 16, 1934, to the Mason-Walsh-Atkinson-Kier Company. On account of technical problems involved, and because the Bonneville project had recently been initiated, the contract was altered June 5, 1935, to cover, instead of a low dam and powerhouse, the base of the high dam originally contemplated. The base of the dam, with high blocks extending above high-water level, was completed March 21, 1938, a year ahead of schedule.

The completion of the dam, the left powerhouse, and the base of the pumping plant is covered by a contract which was let Feb. 7, 1938, to the Consolidated Builders, Inc., a corporation composed of the M.W.A.K. Company, the Six Companies, builders of Boulder Dam, and the General Construction Company, builders of the Owyhee Dam.

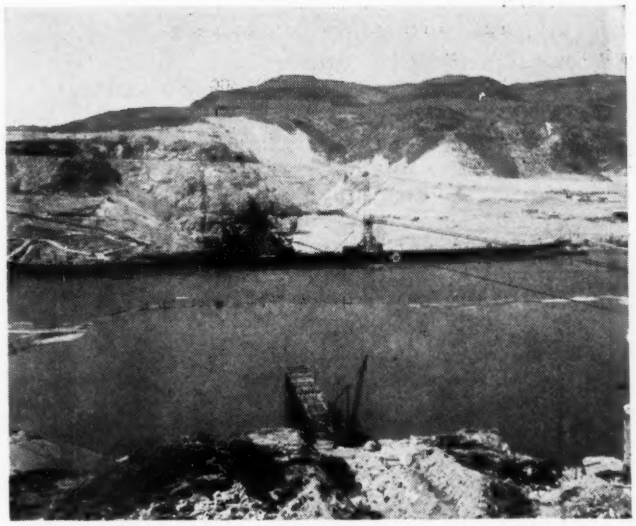
As a preliminary to the building of the dam, it was necessary to build the towns of Mason City for the contractor's employees, and Coulee Dam for the Bureau's staff, a 30-mile transmission line, 30 miles of railroad, improved highways, a 950-ft highway bridge, and numerous construction auxiliaries.

EXCAVATION

Removing 15,000,000 yards of overburden from the sites of the dam, forebays, and tail bays was a major feature of the job.

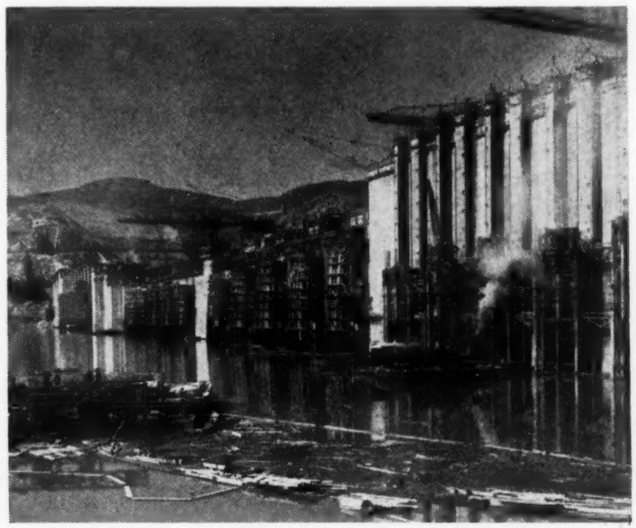
Material, excavated by large electric shovels, was hauled in 8 to 12-yard trucks and 12 to 20-yard tractor-drawn buggies to

COLUMBIA RIVER AT THE MOUTH OF THE GRAND COULEE, SITE OF THE DAM, AS IT APPEARED IN 1933



ONE THIRD OF THE BASE OF THE DAM WAS BUILT INSIDE A 3000-FT COFFERDAM ALONG WEST SIDE OF RIVER

IN 1937 THE COLUMBIA RIVER WAS DIVERTED THROUGH LOW GAPS LEFT IN WEST THIRD OF BASE OF DAM



UPSTREAM FACE OF PARTIALLY COMPLETED DAM SHOWING TRASH RACKS IN COURSE OF CONSTRUCTION

THE DAM, WITH WEST POWERHOUSE UNDER CONSTRUCTION, AND THE GRAND COULEE, SITE OF BALANCING RESERVOIR, BEYOND

WITH ADDITION OF STEEL PIPES AND CANAL, SOME TIME IN THE FUTURE, WATER WILL BE PUMPED INTO BALANCING RESERVOIR

grizzlies over feeder pits, where bulldozers pushed off boulders over 13 in. in size, to be hauled away later in trucks, and forced other materials through the grizzlies.

Feeder belts, shifted from place to place as work progressed, carried the material to the surge feeder on the 60-in. main conveyer system, made up of several sections, each driven by a 200-hp motor, and long or short, depending upon the grade.

More than 13 million yards of overburden were dumped in Rattlesnake Canyon a mile away and 500 to 600 ft above the excavated area, at the rate of a million yards a month—50,839 yards in one 21-hr day. About 3 million yards of overburden from the east shore were carried by a belt across the river on a temporary pile bridge to the main conveyer. Overburden excavation in the vicinity of the dam site exceeded 20 million yards.

The freezing of the toe of a mass of plastic clay, to prevent its movement, was a novel feature of the project.

THE DIVERSION OF THE RIVER

The most precarious, and perhaps the most spectacular, phase of the construction program was the diversion of the Columbia River. A summer peak of 492,000 cfs, raising the water to elevation 981.5, has been recorded; and the maximum flow for 10 of the 23 years for which records were available averaged 445,000 cfs (elevation 978). The contractor's plans for the diversion of the river were based on an assumed maximum flow of 550,000 cfs, and on assumed water elevations of 1000 above the dam and 990 below it. While the cofferdams were in use, the flow did not exceed 400,000 cfs.

At the site of the dam, the river flowed in an 800-ft channel, between sand and clay slopes and terraces against canyon walls 3000 ft apart, with 20 to 70 ft of hard clay, interspersed with boulders, sand, and gravel, covering the granite bedrock beneath it. Into the overburden along the west shore of the river, there was driven in 90 days, in the winter of 1934-1935, the world's largest cofferdam, 3000 ft long, and enclosing an area of 66 acres. Inside the west cofferdam, excavations were made for the west third of the base of the dam, and for a forebay and a tail bay for the left powerhouse.

In order to have the cofferdam completed before the high-water period of 1935, twelve to fifteen heavy trucks operated on a 24-hour schedule, hauling in the 13,000 tons of steel piling from the railroad, 32 miles away. Thirty steam piledrivers, handled by long-boom cranes and derricks, running day and night, drove 127 miles of 15-in. interlocking steel piles. Driving was difficult. An average of 35 blows of 13,000 ft-lb was required per inch of penetration. "Refusal" was fixed at 80 blows per inch. Piles did not penetrate to bedrock, and many were found bent in fantastic curves, when the cofferdams were removed.

Within the west cofferdam, a 1300-ft section of the base of the dam was constructed, with four 50-ft blocks built up only to elevation 910, even with the bottom of the river channel. The three intervening blocks were 40 ft higher. The resulting 350-ft low section was designed as the diversion channel for the river, but to prevent serious eddies and erosion in the tail bay, additional gaps in the powerhouse section, aggregating 225 ft in width, were left at elevation 950.

With the diversion channel completed, the west cofferdam was opened. Cross-river cofferdams, connecting with the outer end of the completed section of the base, diverted the river from its normal course, and inclosed a 55-acre area, in which the remainder of the base of the dam was built.

More than 18,000 tons of sheet piling, 2800 tons of miscellaneous steel, and 18,500,000 board feet of timbers were used in the cofferdam system. Excavations for the cofferdams totaled 1,328,735 yards, and fills 1,502,000 yards. The contractor's reported cost of the river diversion was nearly $6,000,000.

BEDROCK AND BEDROCK GROUTING

The dam rests on granite, a spur of the Okanogan Highlands, once submerged in lava flows, and later exposed and eroded deeply by the Columbia, as it cut its 1600-ft canyon west along the Okanogan Highlands and south along the Cascade Mountains, to form its Big Bend in the northwest corner of the Columbia lava plateau. The rock is coarsely crystalline except where fine-grain, much-jointed, gray granite was intruded. Diamond-drill holes aggregating 33,000 ft, and including holes 880 ft deep, proved the rock adequate for the load it was to bear.

Like other igneous rocks, the granite underlying the dam is seamed with shrinkage cracks. For the purpose of reducing or preventing the seepage of water under the dam, and the development of uplift pressure, bedrock is grouted.

At Grand Coulee, bedrock grouting was done in three stages: First, before any concrete was in place, through drill holes about 30 ft deep, spaced 20 ft apart in five rows of the same spacing, extending across the canyon near the upstream boundary of the base; next, through holes drilled diagonally under the dam, to a vertical depth of 75 ft, after concrete had been placed to a depth of at least 50 ft within a distance of 100 ft; and, finally, for the creation of a deep cutoff curtain, through holes 150 to 200 ft deep, drilled from the gallery in the base of the dam, near bedrock. Grouting pressures varied from 50 to 200 psi, in the first stage, to 800 to 1000 psi in the final stage. Some holes "accepted" very little grout; but, in a "sheeted zone," which was much jointed and contained horizontal crevices of considerable size, two holes about 83 ft deep took over 3000 barrels of cement each; and a number of other near-by holes took from 1000 to 2000 barrels.

After cutoff grouting, now in progress, is completed, uplift pressure-relief holes will be drilled in the lower gallery to a depth of 50 ft. They will remain open, to admit to the gallery any water that may seep under the dam.

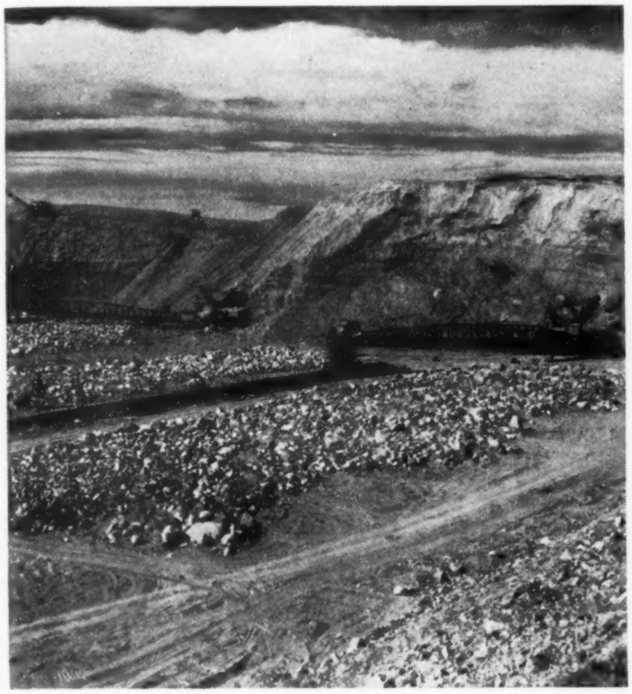
PLACING THE CONCRETE

Concrete was distributed by means of high steel trestles, over which it was hauled in 4-yard buckets, four to a standard-gage flatcar drawn by a 10-ton Diesel-electric locomotive, and delivered to long-arm cranes. To cover the base of the dam, two trestles were built out from the opposite canyon walls as the work progressed. One, with its center line 93 ft from the upstream face, averaged 175 ft in height; the lower, with its center line 220 ft further downstream, averaged 95 ft in height. Each carried three standard-gage tracks and, outside of them, rails for the traveling cranes.

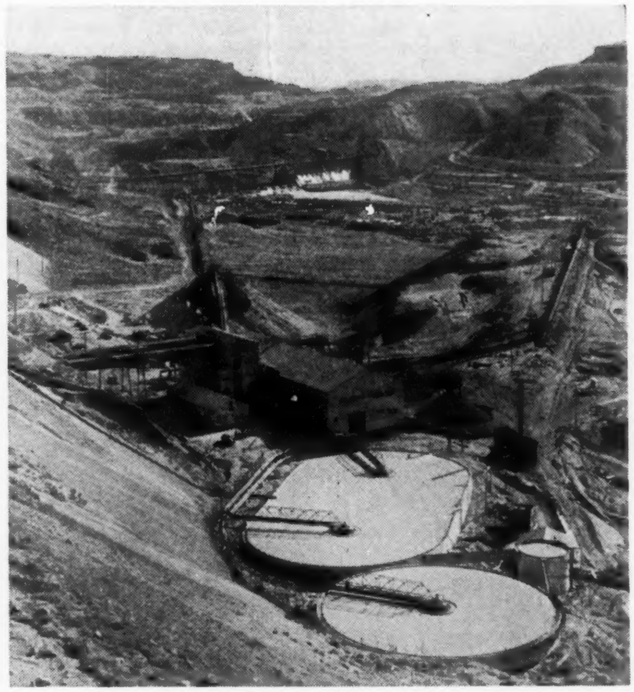
On the base of the dam, a third trestle still in place, 3600 ft long and 185 to 205 ft high, was built to deliver the concrete required for the completion of the dam. It carries four tracks. All but the decks of the trestles have been buried in the concrete. About 25,000 tons of steel were used in the trestles.

Cranes of two types are used. One type consists of Wiley Whirleys, with 110-ft booms, mounted on traveling towers spanning the railroad tracks; the other is a double-cantilever gantry. The Whirleys are especially suited to the handling of forms, equipment, and supplies, and were used to extend the trestles for the base of the dam. They can handle only about half as much concrete as the double-cantilever cranes.

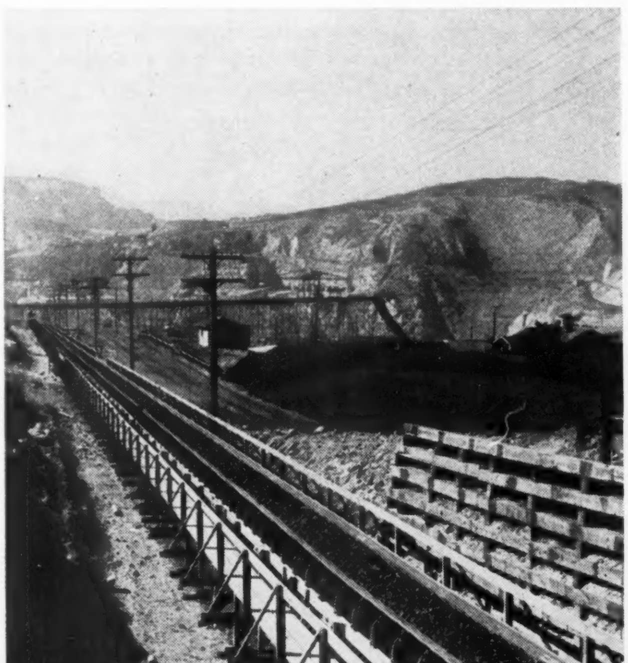
Of the hammerheads, there were seven, four from the first contractor's equipment, overhauled and increased in working span from 230 to 300 ft by Consolidated Builders, Inc., and three new, higher cranes with a working range of 330 ft.



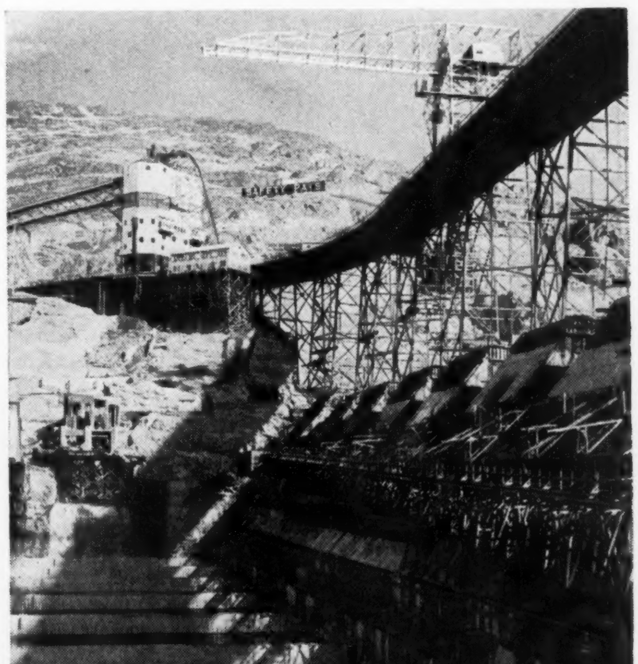
7-YD DIPPERS MOVE SAND AND GRAVEL TO 60-IN. BELT CONVEYER AT RATES AS HIGH AS 75,000 TONS PER DAY. END SECTION OF BELT ON PIVOTED TRUSS ENABLES SHOVELS TO CUT 360-FT SWATH



FOUR SIZES OF GRAVEL (6-IN. TO $^3/_{16}$-IN.) AND CLOSELY GRADED SAND ARE WASHED AND SCREENED IN THIS PLANT FROM WHICH THEY ARE DELIVERED BY BELT CONVEYER TO MIXING PLANT



RUBBER BELT CONVEYER, 10,000 FT (80 TONS) OF 48-IN. BELTING IN A SINGLE LOOP, CARRIES FINISHED AGGREGATE TO DAM AT RATE OF 700 CARLOADS A DAY



TWO COMPLETE CONCRETE MIXING PLANTS IN ONE UNIT—STEEL TRESTLE FOR DISTRIBUTING CONCRETE—FOUNDATIONS FOR FUTURE (EAST) POWERHOUSE IN FOREGROUND

ON THE TRESTLE DELIVERING CONCRETE IN 4-YD BATCHES, FOUR TO A STANDARD-GAGE CAR PROPELLED BY A 10-TON DIESEL-ELECTRIC LOCOMOTIVE OPERATED BY THE HOOK TENDER

They lift 22 tons on a 100-ft arm, lower buckets 375 fpm, and hoist empties 750 fpm. They handled 100 to 160 buckets an hour to points 100 ft below the trestle deck. On them, 440-volt a-c motors drive 250-volt d-c generators and motors with Ward-Leonard controls. Main hoist motors are rated 150 hp.

Concrete is placed in movable forms 5 ft deep, and, except in the powerhouse sections, 50 ft square, according to a pattern laid out before placing was started, the dam being, in effect, made up of a group of columns, composed of 5-ft lifts. Columns are interlocked with vertical keys along upstream and downstream joints, and by horizontal keys along cross-stream joints.

Concrete is dumped through gates in the bottoms of the buckets, in layers 12 to 18 in. thick, and distributed and made compact by means of vibrators. Curing must begin within 8 hr after concrete is placed, and exposed surfaces must be kept wet 14 days. After 72 hr or more, the surface of a lift is cleaned by blasting it with sand, water, and compressed air, exposing uncoated surfaces of sand and gravel to reaction with cement in the coat of grout applied just before the next lift is placed, and insuring a strong watertight bond between lifts.

COOLING THE CONCRETE

Concrete is placed in the dam at temperatures ranging from 60 to 80 F. Reactions between water and cement liberate heat. The consequences are that internal temperatures may reach 130 F, and the concrete mass is expanded beyond the dimensions it is to reach finally, when, like bedrock, it will remain constantly at about the mean annual temperature of its surroundings, that is, at about 50 F.

Shrinkage as the result of the slow conduction and radiation of heat would go on naturally for decades, and many shrinkage cracks, and possibly some leaks, would appear. In order to prevent that, this dam, like others built by the Bureau of Reclamation, was precooled during the construction period, and preshrunk to its final dimensions. That was accomplished by circulating through 2000 miles of 1-in. thin-wall steel tubing, distributed over the surfaces of the 5-ft lifts, cold river water, final cooling to 45 F being completed in winter seasons. A slight rise in temperature, in the course of years, will equalize stresses and put the concrete under compression.

As a result of cooling operations, the 50-ft columns of which the dam is composed shrink about $^3/_{32}$ in., opening up the construction joints between them. Copper grout-sealing strips, buried in the concrete of adjoining blocks, around all openings and along upstream and downstream faces, prevent the escape of the grout which is forced into the contraction joints to make the dam a monolithic mass.

CONCRETE MAKING

Notable records in the making and placing of concrete have been made at the Grand Coulee Dam, the greatest in October, 1939, when 536,264 yards were placed, at an average rate of 17,299 yards a day, requiring each day more than 70 carloads of cement and the equivalent of more than 600 carloads of sand and gravel. The work was carried on with the precision and dispatch of high-grade factory operation.

After the base of the dam was completed, the two mixing plants which had been located on opposite sides of the river were dismantled, overhauled, and reconstructed together at a higher level on the east side of the dam, where they are still in operation.

Each plant includes, at the top, a bin for sand and one for each of the four size ranges of gravel, and two bins for cement, so that either of two types of cement can be used at will. Below them is a batching bin and scale for each concrete component, including water and, on the next floor, a swivel chute

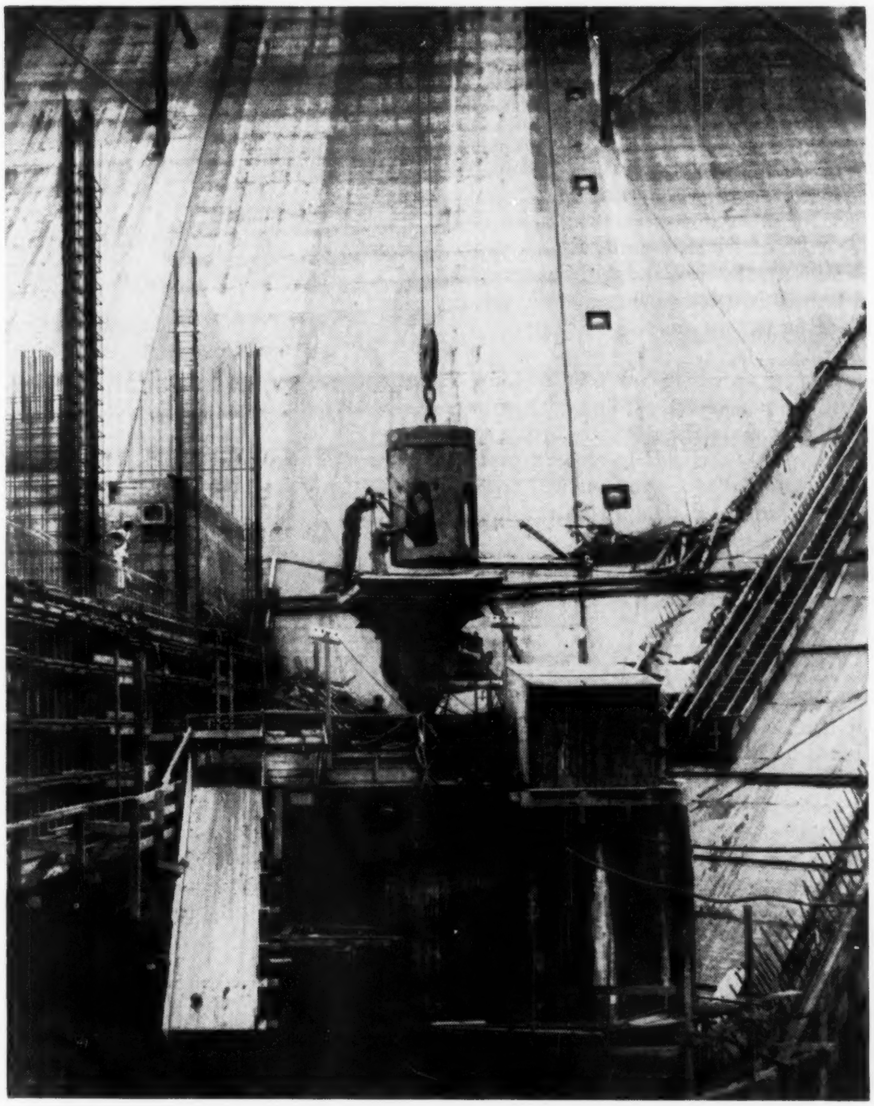
DUMPING A BATCH OF CONCRETE—SIGNALMAN WITH HEADPHONE AT RIGHT IN DIRECT CONTACT WITH CRANE OPERATOR

and 4 four-yard mixers, arranged about a conical delivery chute to discharge the batches of concrete to buckets on cars below.

A dispatcher, who receives his orders from the field office, relays the orders to the batchers by switching on lamps on the batchers' signal boards, to indicate the kinds and number of batches of concrete required. By means of an air valve, a batcher can cause to come into operation one of five sets of scale beams, with weights set to produce concrete of the kind ordered. For example, if the uppermost of the beams on all batching scales are used, a four-yard batch of mass concrete containing aggregate up to the 6-in. size, will be weighed out.

The movement of a second air valve in one direction will cause gates under the stock bins to open. Mercoid switches on the scales close the gates when proper portions are weighed out. Pens on a graphic recorder, in front of the batcher, swing to the right and record the weighing of the batches on a moving sheet of paper. When weighing is completed, the batcher reverses his air valve to dump the batch, but dumping does not occur until or unless the mixer operator is ready to receive the batch into a mixer. This electrical interlock insures safety and speed in plant operation.

The four mixers in each plant are under control of one operator. By push-button control of a motor, he can set the swivel mixer-loading chute in rotation. It stops automatically opposite a mixer. The movement of an air valve couples the chute and mixer, and a batch can be dumped. During the 17-sec dumping period, the controls on the swivel chute and the mixer are locked.



FEEDING A PRESSURE-GROUTING MACHINE BACKFILLING SPACE BETWEEN 18-FT PENSTOCKS AND WALL OF 24-FT OCTAGONAL TUNNELS

A mixer cannot be dumped until controls are unlocked by a time clock measuring the 2-min mixing period, and, also, by a signal from a trainman, indicating that a bucket is in place below, ready to receive the batch.

CONCRETE AGGREGATES

The necessity of preparing and transporting several million yards of washed and closely sized sand and gravel justified the construction of an unusually large and efficient plant.

Aggregate is obtained by the contractor from a pit two miles below the dam, furnished by the government. Material is moved from the pit face to an 18-in. grizzly at the end of a conveyer system, by electric shovels equipped with 7-yard dippers. Oversize is rejected from the conveyer system and, from time to time, is hauled away to a crusher.

The grizzly is mounted over a feeder bin at one end of a steel truss which carries a 60-in. belt conveyer; that end of the truss being supported on tractor treads, and the other on a movable swivel carriage astride a stationary belt conveyer. By swinging the outer end of the truss above the swivel carriage, and advancing it on rails parallel to the stationary conveyer, a 360-ft swath is cut into the pit face.

A large jaw crusher at the end of the pit conveyer breaks oversize rocks to 10 in. or less; and two 20-in. gyratory crushers in the secondary crushing plant, on the hillside below the pit, break coarse material to 6 in., the upper size limit for aggregate.

Four large vibrating screens, fed in pairs by two belt conveyers running in tunnels under the pit-run stock pile, take out cobbles (6 to 3 in.) and coarse gravel (3 to $1^1/_2$ in.); and eight screens separate the intermediate ($1^1/_2$ to $^3/_4$ in.) and the fine gravel ($^3/_4$ to $^3/_{16}$ in.) from the wash water and sand, which go to Dorr thickeners. They feed excess wash water and suspended fines to two large clarifiers, and the sand to hydraulic classifiers. Sand is washed in three size groups, and part of it is blended to a fineness modulus of 2.5 to 3.0. About half the total output of the pit goes to waste as excess sand. The pit output has run as high as 75,000 tons a day.

Aggregates, kept separate as to size until the final batch weighing is done, are moved to stock piles near the dam by 48-in. conveyer belts, one section of which, said to be the longest conveyer belt in the world, contains 80 tons of cotton and rubber in one endless loop nearly two miles long. Other conveyer belts, under the remote control of an operator in the

top of the mixing plant, move different kinds of aggregate into the mixing plants, as required.

CEMENT

Cement, furnished by the government, may be of the standard, modified, or low-heat types, which differ chiefly in volume change and heat of hydration, which are progressively less in the three cements, in the order named. In modified cement, and to a greater extent in low-heat cement, the percentage of tricalcium silicate is limited. The compounds of lime with alumina, and with iron and alumina, are also limited. Fineness is specified in terms of surface exposed, which must average 1800 or more sq cm per g, and be not less than 1600 in any one sample.

Cement moves in bulk, in boxcars assigned to the service. Deliveries have exceeded more than 100 cars per day, and have averaged more than 50 cars a day over long periods. More than 43,000 carloads have been used. Cars are unloaded by means of Fuller-Kinyon pumps, and the blended products of several mills are pumped to the mixing plant through 8-in. and 14-in. pipes 6200 ft long.

COSTS AND COMPLETION DATES

The dam, the west powerhouse, the base of the pumping plant, three main generating units, and two station-service units will be completed early in 1942. The estimated final costs are: Dam, $119,000,000; power plant, $67,000,000; irrigation system, $208,000,000, the financing of the two latter items being distributed over several decades. It is estimated that the total required financing will not exceed $260,000,000. Income from sales of power and from repayments by landowners will finance the later development. The government will recover the entire cost, including $3^1/_2$ per cent interest, except on such construction costs as are allocated against landowners for irrigation works, and will realize an income of $15,000,000 a year from the sale of power.

MARKETS FOR POWER

Since 1920, power requirements in territory within reach of the Grand Coulee Dam have increased at a rate in excess of $9^1/_2$ per cent, compounded annually. The rate of increase since 1934 has exceeded the average, and may continue to do so but, if it falls from 8 per cent to 4 per cent in the next 30 years, half of the increased consumption will load the Grand Coulee plant in 15 years; and, at $2^1/_4$ mills per kilowatthour, the cost of the dam and power plant will be liquidated in 50 years, with a surplus of $144,500,000 to apply on the irrigation system, and an annual surplus of $15,000,000 thereafter.

A large part of the output of the power plant at Coulee Dam will be used by the population of the area to be irrigated; and great quantities will be used in metallurgical operations which will provide industry with gold, silver, copper, aluminum, lead, zinc, antimony, cadmium, magnesium, tungsten, manganese, and other metals.

THE IRRIGATION PROJECT

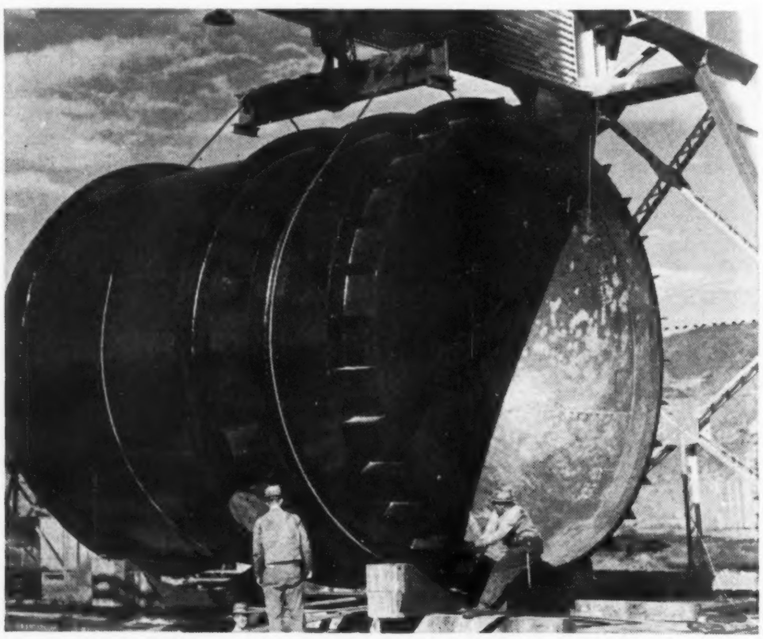
The land to be irrigated lies within an area about 60 miles wide, east and west, and 85 miles long. It consists of dry farms, abandoned farms, and sagebrush desert and grazing land. The greater part of it is owned by individuals and corporations.

In order to protect settlers from speculative land prices, and to insure that many farm homes will be established on the land, Congress, in 1937, passed the so-called Anti-Speculation Act.

It provides, among other things, that water will not be available to land unless holdings are limited to 40 acres for an individual or 80 acres for a husband and wife, and that owners of land in excess of such areas sell the land at its unirrigated value, without increment on account of prospective irrigation, as determined by impartial appraisal by the government.

In order to appraise the land and improvements properly, the Bureau is retracing original surveys, making topographic maps, sampling and classifying soils, and having property evaluated by qualified local appraisers. Records of land classification and appraisals are open to inspection by prospective land buyers.

No part of the irrigation project will be constructed until irrigation districts representing the landowners complete the negotiation of a repayment contract with the government, and Congress makes appropriations to finance construction.



PENSTOCK LINING 18 FT IN DIAMETER CLOSED AT UPPER END WITH HEMISPHERICAL BULKHEADS TO BE CUT OUT AFTER TURBINES ARE INSTALLED

GRAND COULEE *and* ELECTRO-METALLURGICAL INDUSTRIES

By A. E. DRUCKER

DIRECTOR, MINING EXPERIMENT STATION, AND STATE ELECTROMETALLURGICAL RESEARCH LABORATORIES, PULLMAN, WASH.

THE future development of the chemical and electrometallurgical industries in the Pacific Northwest will depend upon: (1) The development of low-priced water-power resources; (2) economic surveys to determine the extent and character of known mineral deposits; (3) proper laboratory investigations to work out the economic metallurgical methods of extraction; (4) checking of the results of the laboratory by commercial (pilot-plant) tests; (5) a survey of markets for products; and (6) a consideration of costs, transportation, and taxes.

The Grand Coulee project will furnish primary (firm) power at a cost of about 1.65 to 2 mills and secondary power at 1.0 mill per kilowatthour for such industries—a price which will be possibly the cheapest in the nation, and the State College of Washington is conducting surveys and experiments so that this low-cost hydroelectric power may be effectively utilized in the production of light metals, alloys, and fabricated products, electrolytic manganese, chromium salts, electrothermic zinc, iron and steel from scrap iron, calcium carbide, fused-silica-glass brick, airplanes, buses, and trucks, from known reserves of raw materials in Washington and the Pacific Northwest.

LIGHT METALS

The increasing importance of the lighter metals, aluminum and magnesium, for use as alloys in construction makes the results of these experiments important to this region. There are large deposits of raw material capable of producing in the State of Washington magnesium and aluminum metals which cannot be developed under present conditions, but which can be made available when cheap power from the Coulee Dam and new methods of extraction are fully developed.

ALUMINUM

The only ore at present that can be employed in the manufacture of aluminum under existing commercial production methods is bauxite, a hydrated oxide of aluminum. It occurs at a number of places in the world, but high-grade deposits low in silica are not numerous. The present process is limited to bauxite containing less than about 3 per cent silica. Reserves of bauxite ore in this country are limited and there are no known suitable deposits of bauxite within the western states. In fact, suitable bauxite deposits in the United States are fast being exhausted. Producers are now forced to go to Dutch Guiana, South America, for a suitable grade of bauxite for the production of high-grade aluminum. The Aluminum Company of America has decided to erect an aluminum reduction plant at Vancouver, Wash., and also in this state at the same location a pig-iron and steel plant will be erected. The bauxite ores from Dutch Guiana, South America, after refining at Mobile or East St. Louis will be transported by ships through the Panama Canal to Vancouver.

Large deposits of suitable clays with high alumina (30 to 40 per cent) and low iron content are to be found in eastern Washington and northern Idaho and, with the development of economic methods of extraction for aluminum and other available by-products such as high-grade kaolin, silica sand, muscovite mica, aluminum sulphate and alumina, and low-cost power, these extensive clay beds, after washing, should in the not distant future become of considerable value.

MAGNESIUM

The State of Washington, so far as is known at present, has the greatest magnesite deposits of economic importance (15 to 28 per cent magnesium-metal content) in the United States. These magnesium ore deposits in Stevens county can be utilized in consuming large amounts of Grand Coulee power. Magnesium metal, extracted from Manchurian magnesite ore, is now being utilized in Japan for aircraft construction. It is a (35 per cent) lighter metal than aluminum and possesses similar qualities and in some ways superior properties for the making of structural alloys for airplane construction, parts of new streamline trains, coal cars, railway equipment, automobiles and trucks (both bodies and motor parts), farm machinery, portable tools, bridges, and all the various structural shapes for construction work.

At present magnesium metal produced from the salt brines of Michigan is on a competitive price basis (volume for volume) with aluminum. Aluminum in carload lots sells for about 19 to 20 cents a pound while magnesium in similar amounts sells for about 28 to 30 cents a pound. Magnesium has less than two thirds the specific weight of aluminum.

NEW ELECTRIC FURNACE ARC PROCESS FOR MAGNESIUM METAL

The direct carbon-reduction and distillation process of obtaining magnesium metal is briefly as follows:

Crude magnesite ore, pulverized and treated by two-stage flotation, yields high-grade magnesite concentrate. This is calcined[1] and then mixed with a small amount of carbon (30 per cent charcoal, coke, or coal) and fed into a reaction chamber heated to about 2300 C by an electric arc. At this temperature the ore is reduced and vaporized. The vapors escaping from the furnace are instantaneously chilled in an oil spray to 200 C, and the fine magnesium-metal powder is condensed and collected in a crude oily condensate. This is first heated in a retort to distill and recover the oil and is then heated to a higher temperature in another retort to distill and separate pure magnesium metal from a residue consisting of impurities and unreacted ore and carbon which may be treated by a second operation to recover more metal. The powder contains from 60 to 70 per cent of its weight in metallic magnesium. A recovery of 80 to 90 per cent of the magnesium content of the magnesite ore in the form of metal in the condensate is possible in practice. The

Contributed by the Process Industries Division for presentation at the Fall Meeting, Spokane, Wash., Sept. 3–6, 1940, of The American Society of Mechanical Engineers. Slightly abridged.

[1] By-product carbon dioxide (one-half ton per ton of magnesite) is used for making solid carbon dioxide.

recovery of the magnesium content going to the distillation furnace is about 98 per cent. The over-all recovery of better than 80 per cent of the magnesium metal content of the calcined magnesite is possible. This electrothermic magnesium metal is superior to the electrolytic grade from salt brines.

By this simple direct process the total power consumption is about 10 kwhr per lb of magnesium metal recovered which is less than used in aluminum production. The cost of this much lighter metal is considerably below that of aluminum, and in my opinion the cost of production from magnesite would be less than 10 cents per pound on a basis of 50 tons of metal per 24 hours. Such high-purity electrothermic magnesium is much more resistant to corrosion and produces superior alloys. Magnesium by this new electrothermic process is actually of better quality, less corrosive, and of higher strength than that which is produced by the present-day electrolytic process.

Such a huge difference between the cost of producing one pound of electrothermic magnesium and the value of the extracted metal from the magnesite ore is a challenge to metallurgists. The Pullman Unit of the Metallurgical Division of the U. S. Bureau of Mines has undertaken to meet this challenge, and the preliminary laboratory furnace developments, during the last three years, have been completed with the cooperation of the State College of Washington. An independent study was started at Pullman, and successful tests on a small scale were finally developed after more than two years of furnace developments and operating details. This process of direct carbon reduction and distillation as finally selected differs in many important details from the German-Austrian process described in the literature. In my opinion these are distinct improvements toward the simplification of this important process. The scarcity of helpful information on the Austrian process required the Pullman staff, under the direction of H. A. Doerner, to develop many interesting details of furnace equipment and procedure.

A new, small pilot plant for continuously producing 100 lb per 24 hr of high-purity electrothermic metal from Washington magnesite with many new automatic features is now under construction on the Washington State College campus. There are now seven full-time members of the research staff on magnesium under Mr. Doerner's direction.

Mr. Doerner expects "that industrial procedures and operating costs can be demonstrated in this unit." He recently stated at the dedication of the Bureau of Mines Station's new laboratories at Salt Lake City:

> Magnesium metal produced by this method is exceptionally pure and resistant to corrosion. The impurities that are found in electrothermic magnesium are of a different kind and less harmful than the impurities present in the electrolytic metal.
>
> Magnesite of adequate purity for the requirements of this process can be obtained by selective mining or by selective flotation of run-of-mine ore. The electrothermic reduction and distillation process is particularly adapted to the use of this raw material.

FIELD OF APPLICATION FOR ULTRALIGHT MAGNESIUM ALLOYS

An article in the May, 1940, issue of *Metals and Alloys* states the following:

> The greatly increased use of magnesium in the aircraft industry during 1939 reflected not only the enlarged aircraft production but also the fact that magnesium is being employed in many more parts of the airplane, says a report of the U. S. Bureau of Mines. The year witnessed the first production in the United States of magnesium-alloy sheet for interior cabin parts of airplane transports. Sheets, bars, extrusions, etc., were fabricated by riveting or electric-spot-welding into such fuselage assemblies as doors, hatches, floors, seats, instrument assembly panels, screw-machine parts, stiffeners, baggage compartments, partitions, air ducts, etc. Sheets and extrusions also were used experimentally in wing sections.
>
> The largest consumption of magnesium alloy, however, was in the form of castings, chiefly sand castings. Sand castings were used for control columns, fuel-valve mountings, engine control brackets, rudder pedals, carburetor air scoops, blower sections, thrust-bearing and camshaft housings, rear sections, diffuser plates, landing and tail wheels, engine-starter parts, pump bodies, and for many other major and accessory parts of aircraft engines. Die castings were used for rocker box covers, valve-rod guides, rib slats, filler blocks, seat castings, and other small parts. Forgings were used for highly stressed parts such as gear housings and diaphragms and in 1939 magnesium tubing was introduced in airplane construction, especially for electrical conduit systems.
>
> There also was a broader adoption of magnesium products in 1939 by certain nonaircraft industries such as textiles, sewing machines, automobiles, conveying equipment, typewriters, and other business machines, and heavy machinery.

METALLURGICAL FUTURE OF STATE OF WASHINGTON

During the last seven years, the State of Washington has been actively engaged in various electrometallurgical research problems, and has published reports, bulletins, and information circulars on this work. Definite progress is being made with magnesium, manganese, chromium, and aluminum Pacific Northwest ores, and by the time the power of Grand Coulee is available to the region, it is reasonably certain that these investigations will make clear the possibilities of utilizing certain mineral deposits within the state and the Pacific Northwest for the establishment of permanent industries.

It is hoped that a path toward a more prosperous territory will be opened by carefully planned researches. The intelligent use of the information furnished by the federal and state geological surveys as well as the results of the U. S. Bureau of Mines and the State Electrometallurgical Research Laboratory at Pullman should gradually bring about a large utilization of the power generated at the Grand Coulee Dam. Washington and the Pacific Northwest should become an important electrometallurgical and chemical manufacturing region during the next 25 years. In fact some industries are already under way at the present time.

New possible electrochemical and electrometallurgical industries for the Pacific Northwest, utilizing low-priced primary and secondary electrical power from Bonneville and Grand Coulee dams, the raw mineral resources of the region, and tidewater plant locations where necessary, are electrothermic magnesium, electrolytic aluminum, electrolytic manganese, chromium salts, and electric-furnace iron and steel from scrap iron. There also exists a possibility of an electrothermic zinc industry.

The most feasible new metal-fabricating industries for this region are ultralight structural magnesium alloys and fabricated shapes for transportation equipment, magnesium sand and die castings, airplanes, flying boats, buses, trucks, railway rolling-stock parts from light metals, aluminum and magnesium-alloy mine cages, skips, cars, and shovel dippers. These are real possibilities. Aluminum and magnesium cans for the great canning industry of the Pacific Coast and Alaska, fabricated shapes and castings of iron and steel, and carbon and graphite electrodes for electric furnaces are also future industries for the Pacific coast. Electric-furnace glass building brick and blocks is another industry that deserves consideration. Among the most probable nonmetallic industries are the phosphate fertilizers for the farms of this region, calcium carbide from Washington limestone and coke, silicon carbide, abrasives, and refractories. All of these are electric-furnace products. Acetate silk from the Olympic Peninsula hemlock cellulose and acetic acid derived from electric-furnace calcium carbide are further possibilities.

The FUTURE *of* POWER USE *in the* PACIFIC NORTHWEST

By H. V. CARPENTER

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THOUGH Lewis and Clark made their historic visit to the Pacific Northwest in 1804, and small settlements around Astoria, Vancouver, Walla Walla, and Salem were developing in the 1830's, the real development of the region awaited the coming of the Northern Pacific Railroad in 1880.

When the potentialities of the Pacific Northwest are considered in relation to the present developments, the region may still be classed as an industrial frontier. In spite of its large cities and tremendous lumber industry, an analysis of the flow of commerce from the Northwest to other parts of the United States indicates that, in a commercial sense, it yet is more of a province than a normal component of the nation. Materials shipped out of the region are largely rough forest and agricultural products, while the imports are mainly manufactured goods. Figures show that the value added by manufacture per capita in the four Pacific Northwest states is 75 per cent of the national average but, if forest and allied products are eliminated, the ratio drops to 35 per cent, indicating a decided weakness in general manufacturing, which is so vital to balanced regional economy.

The need for balance in industrial trade is much greater for the Pacific Northwest than in similar areas where distances and transportation costs to other centers are far less. This deficiency in industrial development is emphasized by the presence in the Northwest of about 40 per cent of the remaining undeveloped water power of the United States and a much larger percentage of this power that can be developed at a reasonable cost.

NOTABLE NORTHWEST POWER PROJECTS

The attention of the nation has been directed to the Northwest by the Federal development of two great hydroelectric projects, Bonneville (483,000 kw ultimate) and Grand Coulee (1,890,000 kw ultimate). The understanding is quite general throughout the country that the output of these plants will not be marketable within any reasonable period of time. This would seem to be true from the fact that the present installed capacity of generating stations in Washington and Oregon amounts to about 1,000,000 kw in hydroplants and about 400,000 kw using steam. These plants have been able to carry the load up to the present time. However, the steam plants have been operated quite consistently during low-water periods for the last few years and additional construction by the operating companies has been held back only by the prospect of low-priced power from the Federal plants.

A careful analysis of the flow of streams and storage facilities of the hydroplants indicates that the installed generator capacity cannot be accepted as that available during the average low-water period, but would be reduced to around 613,000 kw for the average year, with the possibility of its being much lower during some unusual season. Large existing and possible power developments in near-by British Columbia have about the same low-water period each year so that there could be no very great gain by interchange of power across the line. The entire available steam power, totaling 400,000 kw, has been used in recent periods and a part of it for long low-water seasons. Only three or four plants in the area are able to store enough water to maintain full rated operation through the months of August, September, and October. These include, 222,000,000 kwhr of storage at Lake Chelan, 277,000,000 kwhr at Lake Cushman, and 264,000,000 kwhr at Flathead Lake in western Montana; each approximating the December demand for the State of Washington. There is no great diversity in date of low water among the plants included within the basin of the Columbia or Puget Sound, except on the Columbia itself. On this point the Columbia is valuable since its major branch is fed by the great Columbia icecap of Canada, the discharge averaging, during the month of September, about 40 per cent above its minimum with more than double its minimum flow in August.

Two units are running at Bonneville and were carrying a maximum of 77,000 kw during November, 1939. Four more are being installed to bring the total capacity to 283,000 kw which, with three under order for early installation at Grand Coulee, will bring the Northwest total to 1,226,000 kw available at average low water until pumping for irrigation starts at Grand Coulee. Finally, with Grand Coulee and Bonneville complete, the September capacity will reach 2,300,000 kw, besides supplying the 500,000 kw required for pumping for the Columbia Basin irrigation district. Since this is roughly 130 per cent more power than the present demand, there is considerable basis for questioning the need for so great a plant as that at Grand Coulee with its capacity of eighteen 105,000-kw units. At least this justifies a careful study of the growth of markets within the region of the Northwest transmission system.

Industrial development of the area has been proceeding slowly, due largely to lack of sufficient local population. The population growth has been limited to a considerable extent by the great distances to markets for the surplus products of forests and farms. While local industry is hampered by lack of a large local population, it is also protected by high transportation costs from other manufacturing districts.

One purpose of Bonneville is the improvement of navigation on the Columbia and the primary purpose of the Grand Coulee project is the irrigation of 1,200,000 acres of good land. Students of population say that this irrigation is likely to increase the population of Washington some fifty per cent when considered with a similar increase in opportunities for diversified industries. About 40,000 families will find homes on the land and will be followed by the city people in the usual ratio of three to one.

BASIS OF REGIONAL GROWTH

In predicting the growth and population of a region, one must consider the laws of growth, which almost invariably show a period of beginning, a period of rapid and rather uni-

Contributed jointly by the Process Industries and Power Divisions for presentation at the Fall Meeting, September 3–6, 1940, of The American Society of Mechanical Engineers.

form growth, followed by a period of saturation which continues until a new basis for growth appears. Saturation indicates that the requirements or possibilities of the region have been reached.

Typical curves of this sort are shown in Fig. 1, which indicate the growth of Portland, Spokane, Seattle, and Akron, Ohio. Akron is a good example of the effect upon a community of a new industry, showing both the rapid growth and development and the stabilization or partial saturation. Spokane shows decidedly the date at which the city became fully able to care for the agricultural and mining developments surrounding it.

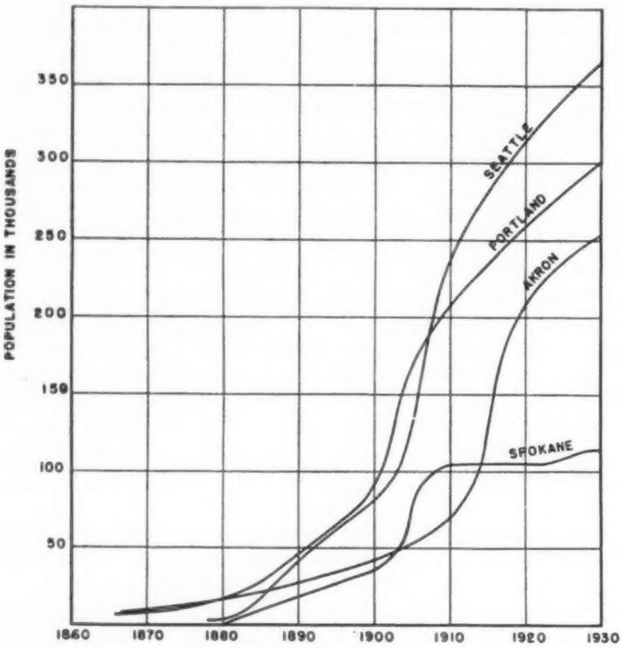

FIG. 1 COMPARATIVE GROWTH OF TYPICAL CITIES OF THE NORTHWEST AND AKRON, OHIO

Seattle and Portland show continued growth but some stabilization since the period following the Alaska gold rush and the development of Pacific trade. From this it appears that the problem of predicting the growth of a city involves the determination of the point at which it stands on its curve of growth. The low degree to which industry has developed in the Northwest, coupled with the unusually low rates for power and the abundance of natural resources within or near the region seems to justify the assumption that none of the industrial cities has passed its greatest period of growth.

GROWTH OF POWER DEMAND BY INDUSTRY

The growth of power demand in the area is shown in Fig. 2, combined with a graph of the year-by-year increase of power, both hydro and steam, available during an average low-water month. The ultimate hydropower available, when Bonneville and Grand Coulee are complete, is also shown. It shows that the demand has increased in the Pacific Northwest in much the same way that it has throughout the nation, i.e., about 10 per cent compounded per year up to 1930. From 1930 through the depression to 1940, the rate has been $4^1/_2$ per cent compounded.

Fig. 2 indicates three simple but different possibilities in future growth. The demand may return to its former curve and rate of growth as it has done following previous depressions, or it may start in 1940 on the old rate of 10 per cent, or it may continue at the recent rate of $4^1/_2$ per cent. Most people would agree, it is believed, that the last assumption is quite sure to be definitely worse than the truth. Very few would hope for it to return to the old curve, erasing the effect of the depression. If we are conservative, and estimate the rate will be from $4^1/_2$ to 10 per cent, we might assume that the demand which is plotted on the basis of reported figures for total kilowatthours used should double by about 1950 or 1951 and reach the 130 per cent additional power supply by 1952 or 1953. Much of this depends, of course, upon the developments in the area to be irrigated, on the rate at which large industries take advantage of the low rates offered by the Federal plants, and also on the increase in use by present and added customers. Domestic demand which has been the mainstay of all companies through the depression, has increased over 80 per cent in the last 10 years, due both to an increase in customers and an increase in use by present customers. This is largely due to new methods of applying electricity usefully in residences.

Much has been made of the increased use on the farm and thousands of farm customers have been added in recent years. Many people have been disappointed in the demand which this has developed for use of power, but it must be appreciated that the equipment needed, especially on the farm, for utilizing power is expensive. In other words, the consumer must spend more per kilowatt of demand than the power company spends in providing the service. So it is likely that the growth of load for both the farm and the residential customer will continue for many years to come, partially due to new devices, but largely because the average small customer is limited in means

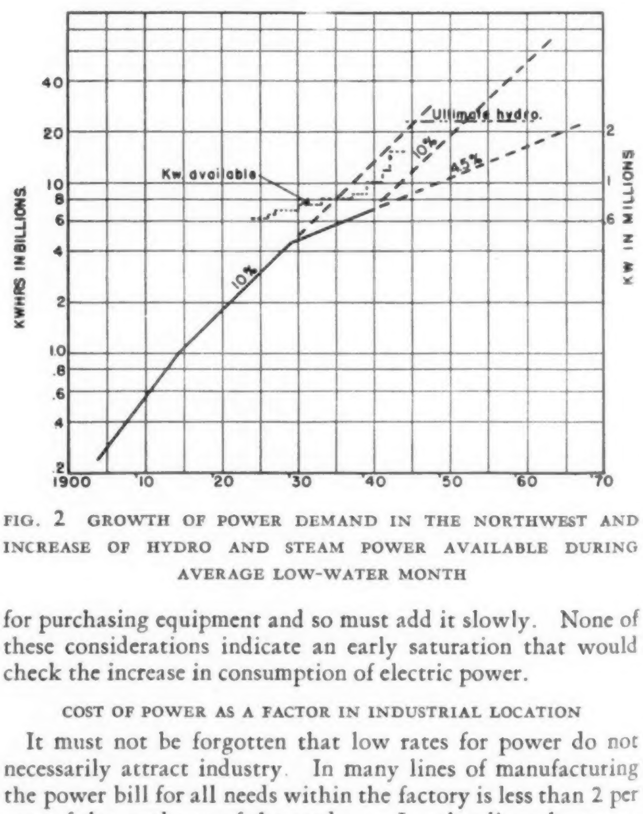

FIG. 2 GROWTH OF POWER DEMAND IN THE NORTHWEST AND INCREASE OF HYDRO AND STEAM POWER AVAILABLE DURING AVERAGE LOW-WATER MONTH

for purchasing equipment and so must add it slowly. None of these considerations indicate an early saturation that would check the increase in consumption of electric power.

COST OF POWER AS A FACTOR IN INDUSTRIAL LOCATION

It must not be forgotten that low rates for power do not necessarily attract industry. In many lines of manufacturing the power bill for all needs within the factory is less than 2 per cent of the total cost of the product. In other lines, however, where comparatively large amounts of power are required and used, the rate for power becomes a major consideration. This point has undoubtedly been a major factor in the recent contract for 65,000 kw from Bonneville for use in a new plant for the Aluminum Company of America now approaching the operating stage at Vancouver, Washington.

(Continued on page 672)

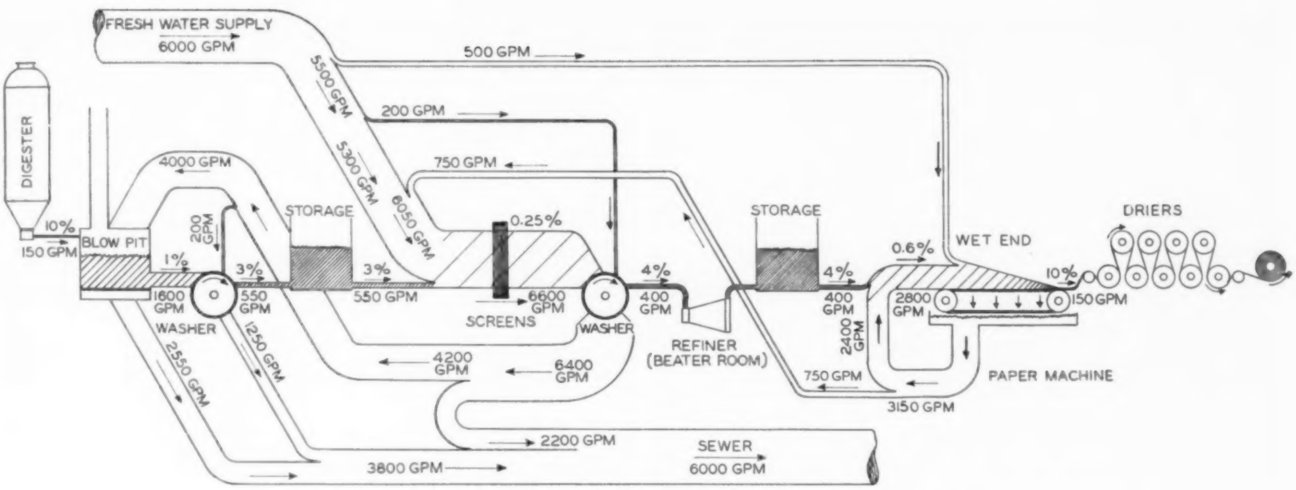

FIG. 1 SCHEMATIC DIAGRAM OF WATER FLOW IN A SIMPLE PAPER MILL

HYDRAULIC PROBLEMS *of the* PULP *and* PAPER INDUSTRY

By M. L. EDWARDS

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HYDRAULICS plays an important role in America's tenth largest industry. This industry, the manufacture of pulp and paper, uses approximately 300 lb of water in making each pound of the paper that it produces. For each person in the United States, approximately 25 gal of water per day are used in making the paper consumed.

In the paper industry, we find pipe lines, tanks, pumps, valves, and flumes acting as the production line; and water as the conveyer belt upon which material is handled.

Water is used as a medium for suspending pulp fiber in manufacturing processes. It distributes chemicals in the pulp and later cleanses the fiber of these chemicals. It carries away impurities. It permits screening and refining and, finally, water is used to weave the tiny fibers together forming the smooth sheet of paper which is so familiar to all.

Fig. 1 shows the elements of a simple paper mill arranged as a schematic diagram of water flow. This diagram is simple when compared to the complicated flow sheet of an actual paper mill. It shows, however, the elements of a simple mill and will provide a basis for discussion.

In order of flow, the diagram shows digester, blow pit, washer, storage tank, screens, washer, refiner (or beater), storage tank, and paper machine. The rates of flow are shown graphically by the width of the flow band. Shaded portions indicate pulp flow. The intensity of shading indicates density of the pulp in the water which is known as "consistency."

The diagram is in perfect flow balance for a uniform production through the mill of 100 tons of paper in 24 hr. The percentages shown indicate consistency which is the ratio of pulp to water. (A 3 per cent consistency would be a ratio by weight of 3 parts of dry pulp to 97 parts of water.)

Contributed by the Hydraulic Division for presentation at the Fall Meeting, Spokane, Wash., Sept. 3–6, 1940, of The American Society of Mechanical Engineers.

The digester is shown delivering pulp into the blow pit at 10 per cent consistency at a rate of 150 gpm. This is an average figure, as cooking in the digester is a batch process. The contents of a full digester is blown into the pit at one time. Pulp is drawn at a uniform rate from the blow pit, however, and is so delivered throughout the mill.

It will be noticed that the pulp enters the system from the digester and leaves the system at the paper drier at a flow rate of 150 gpm and at a consistency of 10 per cent at both points. Also, a flow of 6000 gpm of fresh water enters the system at the top of the diagram, and the sewer at the bottom shows a flow of 6000 gpm of discarded water.

It will be further observed that all points in the flow pattern are in balance. These conditions all contribute to a perfect water balance of the mill, under which conditions all parts of the mill are producing at a uniform rate, the liquid level in the two storage tanks remaining constant.

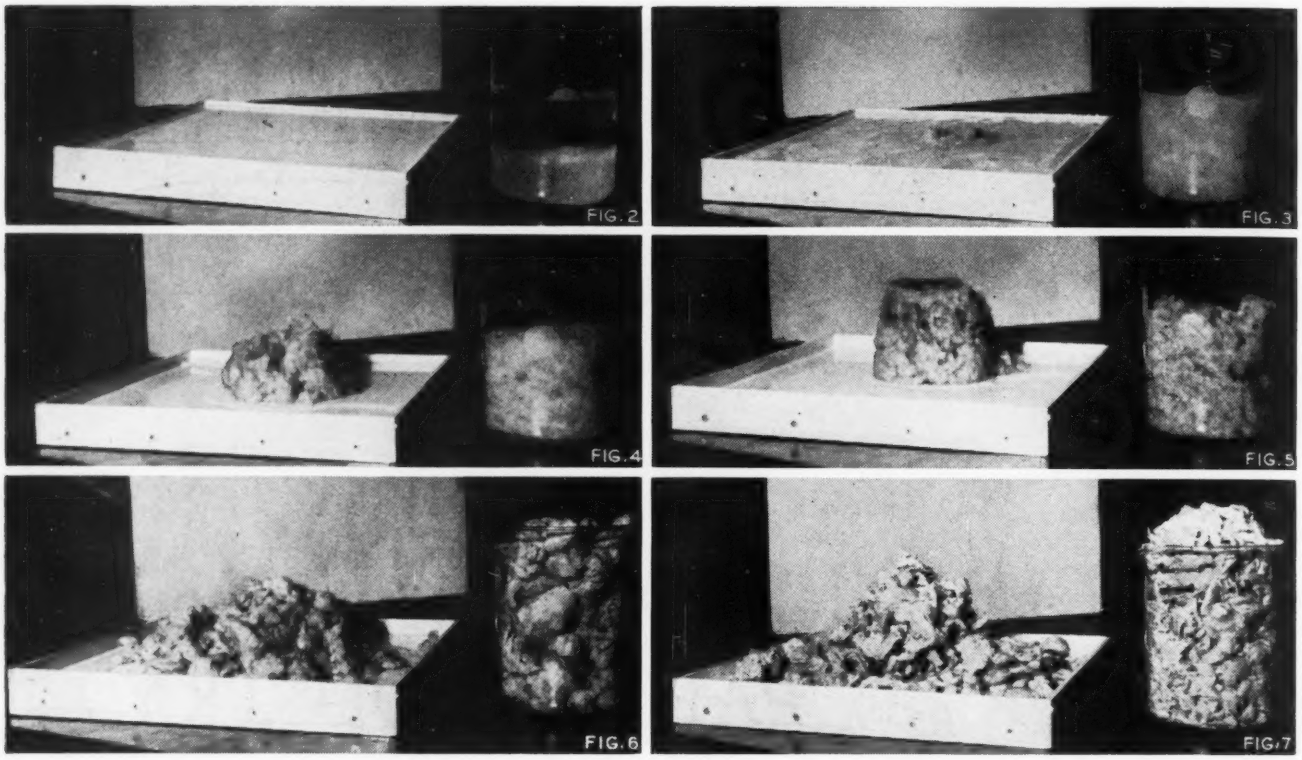
A study of hydraulic balance in a paper mill assists the operator in solving many problems of mill flow and water and stock economy.

PAPER PULP AS A HYDRAULIC FLUID

A thorough understanding of the nature of paper pulp as a hydraulic fluid is a cornerstone in any study of paper-mill hydraulics. The subject bears directly upon the solution of one of the paper-mill engineer's most perplexing problems, which is the flow of pulp through pumps and pipe lines. The subject will be discussed under the heads of consistency, freeness, and entrainment of air.

CONSISTENCY

In a strict sense, paper pulp is the fibrous material of which paper is made. About the paper mill, however, the word "pulp" often refers to a water suspension in which the pulp



FIGS. 2–7 SERIES OF PHOTOGRAPHS SHOWING SOME PHYSICAL CHARACTERISTICS OF PULP IN SUSPENSION OF VARIOUS CONSISTENCIES

fiber, by weight, is a small percentage of the aforementioned total. In other words, the word "pulp" refers to liquid pulp.

The hydraulic qualities of a pulp suspension are, of course, derived entirely from the water. Pulp is a solid. On increasing the ratio of pulp to water from low consistencies, the character of the mixture changes from that of a pure liquid, gradually assuming that of a solid as the consistency reaches the higher values.

The accompanying series of photographs shows samples of pulp of varying consistencies for the purpose of portraying some of the physical characteristics of pulp in suspension. In preparing the photographs a raw, western hemlock sulphite wood pulp was used. The consistencies of the samples vary from $^1/_{10}$ to 20 per cent as indicated. In each picture, two samples of pulp of identical size and consistency have been used. One sample in each case has been dumped into the tray and the other left in the beaker.

The first sample of $^1/_{10}$ per cent has spread out (Fig. 2) as a thin sheet of water over the tray. In the beaker the fiber has settled to the bottom leaving clear water above. The specific gravity of pulp fiber is about 1.4; but on account of the fineness of the fibers, several minutes are required for settling.

At 1 per cent consistency (Fig. 3) the fluid in the beaker is filled with fiber, though the top of the mixture appears to have thinned by settling. In this case the tray shows near the center a slight mound of pulp. The remaining area of the tray is covered with a thin mixture of pulp and water.

At 3 per cent the solid characteristics (Fig. 4) are much more pronounced. The heap of pulp in the center of the tray holds its form quite well, and a quantity of clear water on the floor of the tray indicates that there has been drainage from the pulp. Here the level in the beaker is approximately the same as in the cases of lower consistency. This indicates that there is no great quantity of space taken up by air voids below the liquid level.

At 6 per cent the level in the beaker (Fig. 5) is somewhat higher, indicating air voids in the pulp. These may be readily seen through the glass. In this case the pulp in the tray holds the form of the beaker from which it was dumped, and a small quantity of clear water in the rear of the tray indicates slight drainage.

At 10 and 20 per cent consistency (Figs. 6 and 7) the pulp samples resemble a pure solid. Increased volume in the beaker indicates an increasing quantity of air voids. There is no drainage by gravity. Pulp at these consistencies, however, will give up water upon being pressed. A tank filled with pulp of this type at 20 per cent consistency would readily support the weight of a man walking upon it.

It must be emphasized that these observations on consistency apply to raw, unrefined (unbeaten) chemical wood pulp. The characteristics of other pulps might vary widely.

FREENESS—SLOWNESS

Chemical wood pulp consists of the residue of wood fibers which are left after wood has been subjected to a chemical cooking process. In this process the lignins, resins, and some of the carbohydrates in the wood have been dissolved leaving, after washing and screening, pure fibers each of which is individual and separate from other fibers.

"Freeness" is that quality of pulp which permits it to give up water by drainage. The opposite to freeness, which is "slowness," is the quality of pulp to retain water when drainage is permitted.

In order to understand clearly what constitutes freeness, consider for a moment the individual wood fiber as a piece of material. The photomicrograph, Fig. 8, shows several fibers taken from hemlock wood by the sulphite process. The average fiber here is about $^1/_8$ in. long, and, if it were round in cross section, would be approximately $^1/_{1000}$ in. in diameter. In structure the fiber is tubular; and when wet, the center of the

tube structure is to a degree filled with water. The walls of the fibers are made up of minute fibrillas tightly cemented together.

The factors which enter into the water-retaining qualities of pulp are largely the fineness and softness of the individual fibers. Free fiber, as shown in Fig. 8, is not suitable for forming a good paper sheet but must first be subjected to a beating or refining process. This consists of subjecting the fibers to mechanical abuse by pounding them between steel bars and against stone. The result is a shortening of the fibers, a loosening of fibrillas and a swelling of the cell wall due to the adsorption of water.

Fig. 9 shows beaten or slow stock. Fibrillas which have been loosened from the fiber walls are evident. Fibers are flattened out and broken. The presence of the loosened fibrillas and the swollen character of the fibers resulting from beating give the pulp the ability to retain water or the quality of slowness. In other words, beating or refining reduces freeness.

To illustrate freeness Fig. 10 shows a small, narrow container with glass walls having a horizontal partition made of fine wire mesh. A quantity of pulp similar to that in the microscopic photograph Fig. 8 was dumped into this container and photographed after five seconds had elapsed as shown in Fig. 11 with drainage complete. This is free pulp. The fiber has been held by the wire mesh, and much of the water has drained into the lower part of the container.

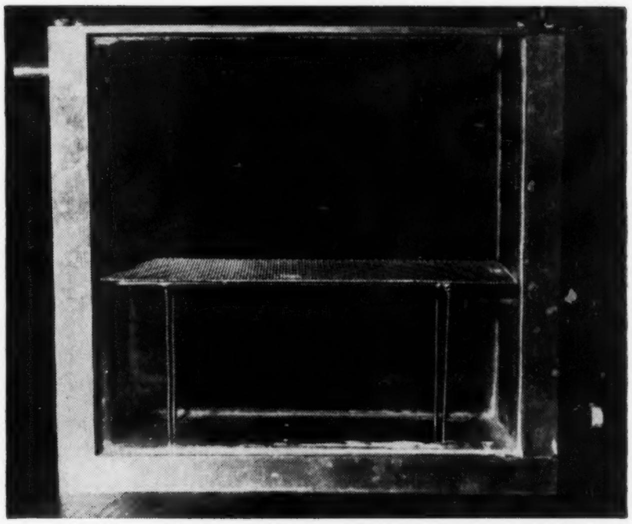


FIG. 10 SCREEN IN GLASS-WALLED CONTAINER TO SHOW FREENESS

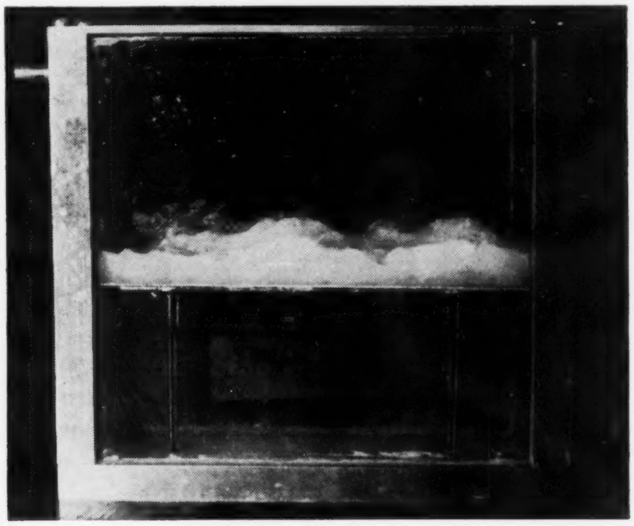


FIG. 11 FREE FIBER AFTER SETTLING FOR 5 SEC

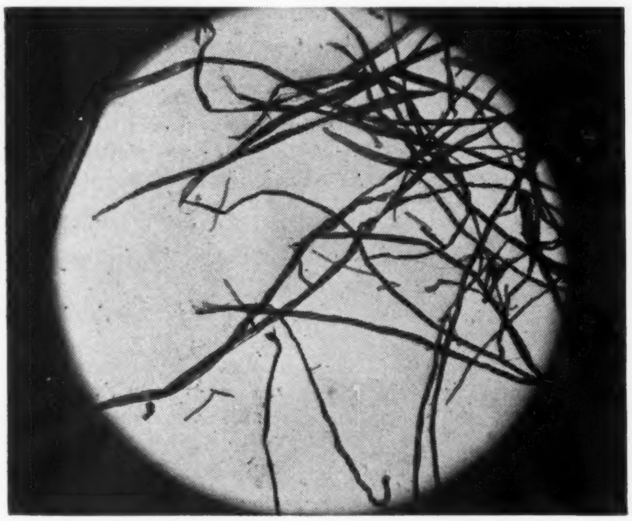


FIG. 8 PHOTOMICROGRAPH OF FREE-FIBER WOOD PULP

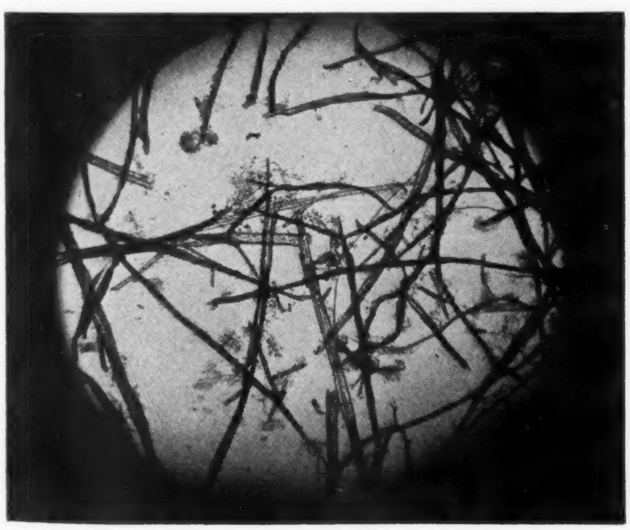


FIG. 9 PHOTOMICROGRAPH OF SLOW, OR BEATEN, WOOD PULP

A second sample was similarly treated. This sample was a duplicate in consistency and quantity to that referred to in the foregoing paragraph except that it was of a beaten stock as shown in microscopic photograph, Fig. 9. After five seconds the water was largely retained above the wire as shown in Fig. 12. This pulp shows a greatly increased ability to retain water. Two and one-half minutes had elasped before drainage was complete as shown in Fig. 13. This stock is slow or has low freeness.

There may be a variance in freeness of stock as it comes from the digester due to severity of cooking. The bleaching process is also inclined to cause some reduction in freeness. Groundwood (mechanical) pulp is very slow at the time it leaves the grinder. Another factor that may influence freeness is the kind of wood or other material that is used in making the pulp.

A number of laboratory tests have been devised to measure freeness. These tests in general consist of a measurement of the quantity of water which will drain from a specified sample through a standardized wire mesh in a given time.

Freeness affects the hydraulic qualities of pulp. Lowering the freeness of a pulp decreases its solid characteristics and in-

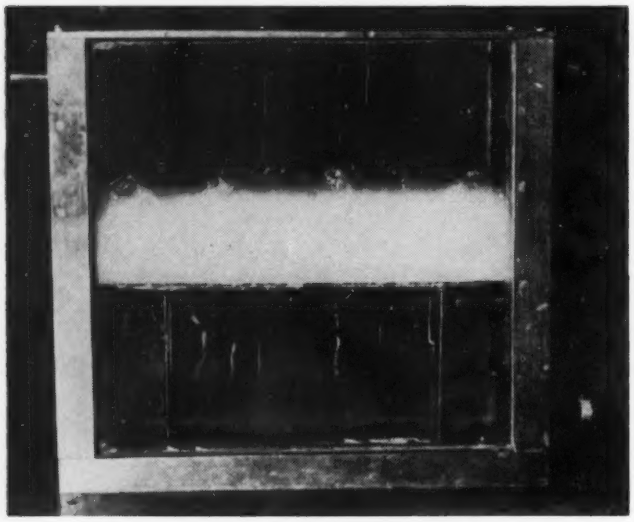


FIG. 12 BEATEN FIBER AFTER SETTLING FOR 5 SEC

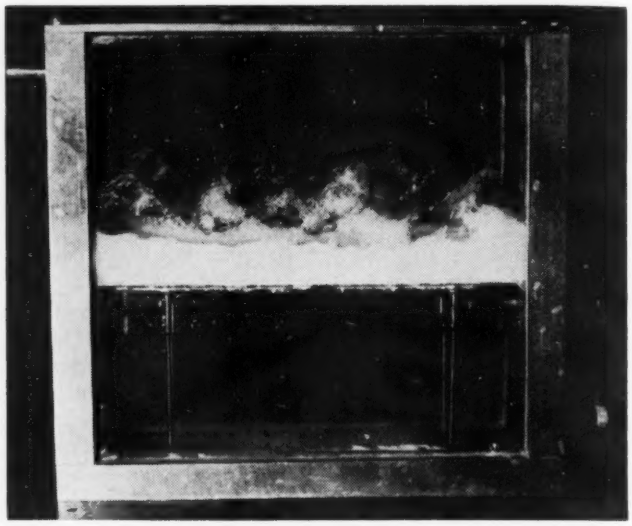


FIG. 13 FIBER SHOWN IN FIG. 12 AFTER DRAINING $2^1/_2$ MIN

creases its liquid properties as already mentioned under the subject of consistency. In other words, from the standpoint of pulp flow through a pump or pipe line, a 3 per cent consistency of free, unbeaten stock might have the same properties as a 4 per cent consistency of slow beaten stock.

It was stated previously that a quantity of stock of 20 per cent consistency would support the weight of a man walking upon it. This might be true of free stock, but probably would not be true of the same stock after beating.

ENTRAINMENT OF AIR

As previously mentioned, an average hemlock pulp fiber is about $^1/_8$ in. long; and if it were round in cross section would be approximately $^1/_{1000}$ in. in diameter. It has a unit tensile strength equal to some grades of steel and for its size has a remarkable stiffness to resist bending. The tubular fiber structure when suspended in water is easily tangled with other fibers or matted into a sheet. It has a marked tendency to flocculate or combine with other fibers into bundles which act as units in flow. These "flocks," as they are called, form in all pulp at high consistencies; and in some cases they occur in consistencies as low as $^1/_2$ per cent. The size of the flocks and their tendency to form depends upon consistency, length and stiffness of the fiber, and the nature of flow to which the pulp is subjected.

Referring to Fig. 4 showing pulp of 3 per cent consistency, flocks are evident as lumps in the tray. In the beaker they are marked by cloudy effects seen through the glass. This tendency is more evident at 6 per cent and still more marked at the higher consistencies.

As has been said, flocks act as units in flow. They may roll or slide in the stream as is necessary to conform to the flow pattern established by the passageway through which the pulp is flowing. If the flow is subjected to violence as in a centrifugal pump, bundles may be broken down; but they are quickly formed again when the violence ceases.

At points in a system of flow where consistency is being changed by adding or removing water, flocks absorb or give up water. When dilution becomes extreme, the bundles are dispersed and the fibers lose contact with each other. At this point the fluid assumes the free-flowing character of water.

All pulp of consistencies which will support flocculation is subject to entrainment of air. In other words, air may be held by any pulp suspension that is dense enough for the entanglement of fibers.

A pictorial study of the entrainment of air is given in the accompanying photomicrographs. Fig. 14 shows an air bubble pressing upward against a fiber flock. Portions of other flocks may be seen in the upper and lower left-hand corners and directly below and to the right of the bubble.

Fig. 15 is an interesting study of a small bubble in the upper part of the picture which has broken away from a larger bubble which appears below. This larger bubble was pressed between two flocks forcing the small one to flow upward between the flocks.

Fig. 16 shows at the left a bubble whose buoyancy has caused slight compression of the flock directly above it, resulting in an area of free water below the bubble.

Fig. 17 shows a group of small bubbles held tightly in the pulp by entanglement of fibers.

The entrainment of air is a serious problem wherever a centrifugal pump is involved. The vortex of the pump separates the air from the pulp and causes it to collect near the center of rotation. Pockets of air thus formed reduce flow and may interfere with production. In some applications special agitating devices are required to relieve the pulp of excessive air.

Troublesome air in pulp has been a subject of research by pump designers since the introduction of the centrifugal pump into this service. Only in the last few years has substantial progress been made in this field.

THE FLOW OF PULP

The delivery of paper pulp through pumps and pipe lines is the paper industry's means of handling material. Many of the pump manufacturers offer a full series of pumps designed exclusively around the problem of handling heavy pulp stock. The style of centrifugal pump generally used for this service is of the single-end-suction type with a large ported compound impeller having two or three open-type blades.

Some pump designers use an inlet connection two and even three pipe sizes larger than the discharge in order to get low velocities on the approach to the impeller. Others prefer a relatively small impeller eye to get low blade velocity at the point the pulp is picked up. The recent tendency has been toward the small inlet size which, in general, is one pipe size larger than the discharge connection.

Some pump manufacturers have advertised their equipment as capable of pumping stock up to 7 and 8 per cent consistency. This may have been done in cases where conditions were ideal, but in general a 4 to 5 per cent free stock is as high a con-

sistency as can be handled with assurance. As the higher consistencies are inclined to carry greater quantities of air, the limiting factor may prove to be air instead of lack of fluidity.

Heavy pulp flowing through a pump or pipe line is greatly retarded by friction. Pipe-line calculations may be made by use of friction curves which are available from a number of different sources. Curves shown in the book of standards of the Hydraulic Institute cover both sulphite and groundwood pulp.

The sulphite curves show greater friction than groundwood. Sulphate or kraft pulp has greater friction than sulphite. Soda pulp falls between sulphite and groundwood. In general, all pulp friction curves refer to free stock of the kind of pulp for which they are drawn. Friction values may be modified if the stock has been beaten.

To illustrate relative values of pipe friction in pulp as compared to water, the curves from the book of standards show in a 6-in. iron pipe at 500 gpm of water flow a friction loss of 3.3 ft per hundred feet of pipe, while 4 per cent sulphite pulp shows a loss of 54 ft under similar conditions.

The location of all pumps for handling pulp stock should be such that the supply will have as much gravity head as possible for feeding into the pump. A suction lift into a pulp pump is sure to be a source of trouble.

A multiple discharge in a line leading from a pump is to be avoided. It is almost impossible to make pulp flow from one pump to two different points of destination at the same time. When this is tried, slight variations in consistency will cause the head in one of the branch lines to rise above that of the other branch line with the result that all of the flow of pulp will be discharged through the branch having the lower head. When this occurs, water will drain from the pulp in the line that has no flow, forming a plug of hard matted fiber. A plug of pulp thus formed may become so hard and tight that it is necessary to disassemble the pipe for removal.

The instrumentation of flow in any pipe line where pulp fiber is encountered is extremely difficult owing to the tendency of the fiber to plug up the small pipe openings by which pressure measurements are taken. Owing to the practice of the industry to operate at a known tonnage or rate of pulp flow through parts of the mill, a close approximation of the quantity of liquid flow may be calculated from consistency tests made at or near the point where the check is to be made. This is done by use of the formula

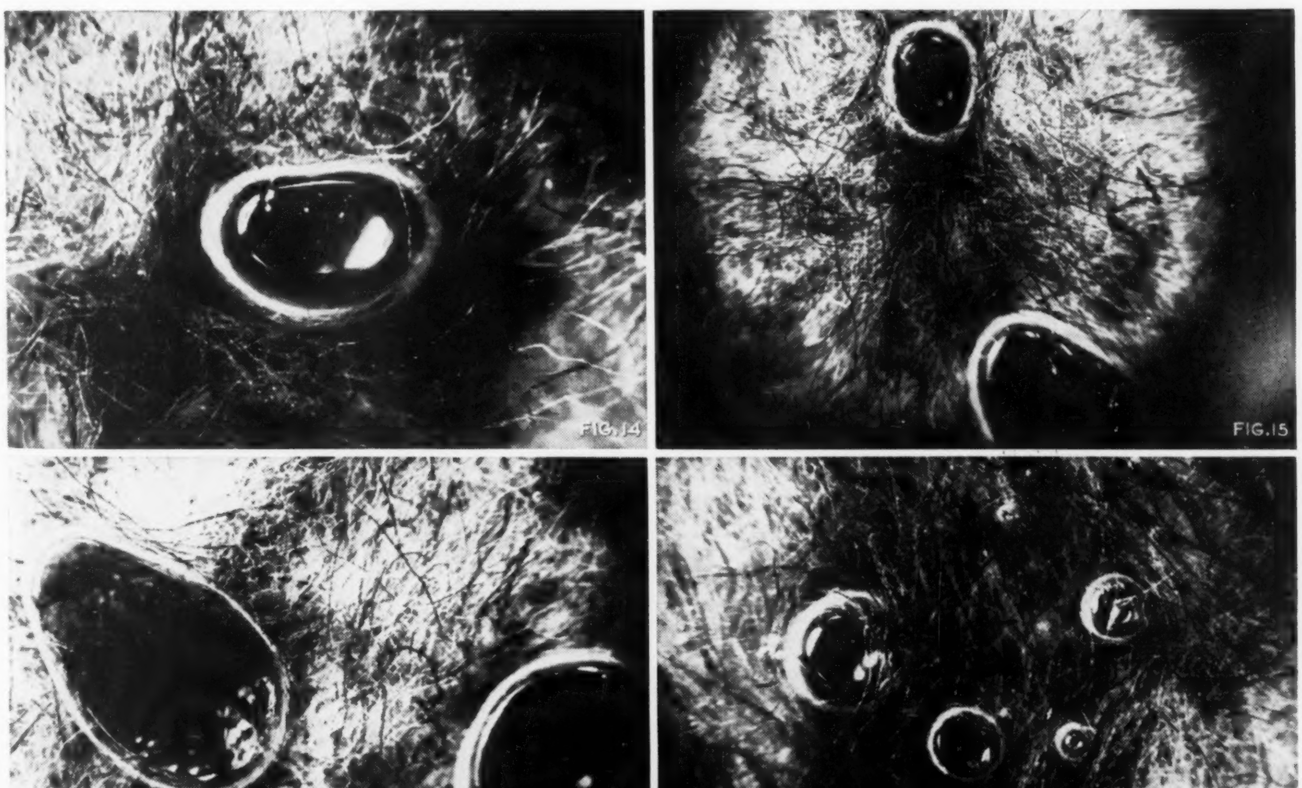
$$\text{Flow in gpm} = \frac{\text{Mill production (tons per day)} \times 167}{\text{Consistency in per cent}}$$

A study of the mill flow diagram Fig. 1 will reveal how universally the method may be used.

As an example in using this method of checking the rates of flow at a point where water is being added to the flow of pulp, consistency samples may be taken from the stream before and after the dilution. The difference between the calculated flow values at these points would give the approximate quantity of dilution water used.

CONCLUSION

This discussion of paper-mill hydraulics has been directed at some of the peculiarities occurring in this particular industry. While hydraulic technique is about the same throughout industry, the exceptions which the author has attempted to describe in this paper are what make it a fascinating profession.



FIGS. 14–17 AIR BUBBLES IN WOOD PULP

The SELECTION *of* MEN *With* CREATIVE ABILITY

By F. ALEXANDER MAGOUN

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THE problem of selecting men with creative ability has two major divisions concerning neither of which do we know much, perhaps because we have been such notorious dawdlers in realizing that "the proper study of mankind is man." There is the problem of defining the characteristics of creative ability, and there is the problem of identifying them.

Any attempt to winnow out the truth by less painstaking methods than a strictly scientific approach is not likely to be rewarding. But within the narrow confines of my own observation, men with creative ability always have (1) original ideas, (2) the capacity to make them workable, and (3) the persistence to keep at it until something is really accomplished.

The old definition of a genius being a damn fool that succeeds is merely a left-handed appreciation of his incommunicable gift for unorthodox ideas. He seems slightly queer to the ordinary person because of his startling ability to perceive the unusual. If he does nothing with his gift, he is only an empty dreamer; if his dissatisfaction with things as they are inflames him sufficiently to do something about it, then he is labeled a crackpot until an ability to make his ideas workable has persisted long enough to bring recognition. After that, everybody joins the adulation.

When discussion is narrowed to so restricted a field as the selection of young men with creative ability, it must not be forgotten that they have just emerged from twelve to sixteen years of schooling, focused on what Dorothy Canfield describes as "the outrageous overvaluation of bookish brains." It is a far cry from remembering what somebody else thought, to actually thinking creatively for yourself.

The dismaying odds against more than a brave and tentative identification of verdant creative ability are at once apparent. And the odds are raised to some exponential function when the decision is to rest on a half-hour interview.

Here then is a problem which our limitations compel us to approach with a slightly hemmed-in feeling: What are the characteristics of an interview which will show whether a man has originality, common sense, and persistence?

The excellence of any interview depends upon three things: (1) The ability of the interviewer; (2) the attitude of the interviewee; and (3) the validity of the diagnostic situations.

THE SKILL OF THE INTERVIEWER

Because a man sits on the questioning end and has the power to hire or to reject is no guarantee that he knows what he is doing. It is not uncommon for a talented senior, pardonably preoccupied with the task of finding the right job, to testify that in only one of the half dozen interviews he has experienced did the interviewer have any intelligent idea of what constituted good method. Consider, for example, the following which was perpetrated by a personnel man from a nationally known company:

"What's your name? Won't you sit down. I want you to take that piece of paper and draw on it an abscissa and an ordinate. Now label the abscissa 'frequency' and label the ordinate 'magnitude of impedance.' Draw the response curve. Now argue your solution. Come on, talk! . . . . All right, now write the derivative of the tangent . . . . . Good. Now draw a simple amplifier . . . . . . That's all, good afternoon."

This was the entire interview. There could be no truth to the answers because there was no truth to the way the questions were put. Here is what happens when an incompetent person tries to imitate good method and gets no further than the superficialities.

A big steel corporation sent out a team of three interviewers: One paced the floor; one asked questions from a typed sheet; the third took notes on the applicants' answers. Isn't this a war of nerves instead of an attempt to discover ability? Progress in science has not been made by men who would submit to regimentation.

Interviews like these are useless because they cannot possibly see the man as a whole in terms of the job. They confuse the tools of the carpenter with the skill of the carpenter; a particularly dangerous way of inviting the thunderbolts because most educational institutions concern themselves primarily with giving the carpenter a full toolbox.

Interviews like these are worse than useless because for all their bland pretense they give a very poor impression of the company. It matters not one whit that the men who conducted them have had years of experience. Practice does not make perfect except under those rare circumstances when one starts with perfect aptitudes which, by the use of *good method* and of *evolving standards of performance*, at last develop into a skill which deserves to be called perfection.

The clumsy and incompetent interviewer will give himself away at once by the use of a chain of questions. How old are you? Where did you go to college? What courses did you take? Did you get good grades in chemistry? Do you think you would like research? He believes he has learned something merely because he now knows that the applicant is an M.I.T. graduate with exceptionally good inorganic-chemistry grades, who, as a high-school student, had a small laboratory down cellar where he used to explore in wide-eyed wonderment the miracle of iron filings and sulphuric acid. Actually, so painfully unimaginative an interviewer has learned nothing of significance. The very means by which he might have penetrated below the surface to the level of the applicant's creative drive were strangled at the outset by poor method. What he is interested in is a very small part of it. Why is he interested? Or perhaps we should summon all six of Rudyard Kipling's serving men:

> I keep six honest serving men
> (They taught me all I knew);
> Their names are What and Why and When
> And How and Where and Who.

It is an area we wish to explore, not a line of predetermined questioning; a whole man in relation to an environment, not

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a passionless record. Consequently, the applicant must be allowed to run absolutely free in order that he may behave naturally, integrating his data, thinking sequentially, or merely rambling as the case may be. The circumstantial evidence of how he organizes and selects his material is usually far more important than the direct evidence of the answer itself.

A skillful interviewer would have begun by saying, "Tell me what you are most interested in and how that interest came about."

To this the student might have answered, "I'm interested in chemistry. As a matter of fact I've been interested in chemistry ever since I was a little boy. My mother began reading fairy tales to me, but they were so gruesome it made me quite unhappy. (Significant information here already.) So she started to read Slosson's 'Creative Chemistry,' and I was fascinated, first by the story and then by the imagery of formulas that are part of a chemist's tools. Later I had a small laboratory in the cellar where I worked out experiments even before we had them in high school. But the most fascinating thing of all, I think, is the sheer beauty of a formula for the chains of giant atoms that make up a plastic."

A penetrative interviewer will already suspect that the creative ability of this sensitive lad is artistic, not scientific; a correct deduction entirely impossible by the first method.

Creative ability, denied its legitimate outlet, often seeks a substitute. The boy who builds model airplanes as an outlet may subsequently distinguish himself as a composer. The models were only a sop to his desire to create during the years before music was available. Parents and teachers will prematurely hail him as a coming aeronautical engineer. A discerning student of human nature will observe that the boy's first thought is always the beauty of his structure, never its theory. There will be harmony between the little planes that he builds rather than any experimental sequence. There will be rhythm in the way he hangs them from the ceiling of his room rather than a notebook filled with data on flight durations and dihedral angles. The element of originality, at once apparent in his music, will be entirely lacking, or nearly so, in the stereotyped imitation of someone else's thinking. The models are something he is creating with his hands but not his mind. A boy with real creative ability in the field would start with something preposterous but original and gradually improve it until at last it functioned.

ATTITUDE OF THE INTERVIEWEE

Reliable results are unattainable unless the interviewee is quite at ease and acting naturally. His attitude will of course be greatly influenced by the emotional habit patterns he brings in from the past. A college boy reacts toward the world in terms of how he has learned to react toward his family. It is important to know what these terms have been. But his attitude will also be affected by active factors such as the personality of the interviewer, on whose shoulders squarely rests the responsibility for establishing rapport.

Some employers proceed as though they were from the district attorney's office, determined to discover something on a fine morning by a bit of trickery or threatened violence perpetrated on a frantic, cornered individual. The police interview on one theory; the psychoanalyst, on the exact opposite. Which comes closer to an understanding of the truth?

No one ever does a good job of interviewing unless he has succeeded in putting the applicant into a frame of mind that brings out his best qualities. This is not to be done by what Elliott Smith calls "the impertinence of irrelevant conversation." Men using good method will not try to play two inconsistent personalities at the same time; one social small talk, and the other careful interviewing. It is not to be done by unwarranted prying, or by seeking only to discover weaknesses. It comes only when the interviewer is sincerely interested in people and is the master of a technique of helping the interviewee to show his truthful best, which deserves to be called out.

VALIDITY OF THE DIAGNOSTIC SITUATION

The scientific approach permits no guesswork. There may be times when one relies upon the leap of an intuition schooled by long and careful analysis, but conclusions are to be drawn only on the basis of objective evidence that is a *valid* criterion.

Parents, teachers, and employers are often conspicuously obtuse in identifying evidences of the creative instinct. The president of one of our largest industrial plants tells of the fine frenzy of enthusiasm with which many a boy has been recommended to him because the lad had built a radio or constructed a fleet of model airplanes. No one of these prodigies ever developed any originality. But one day his office darkened ominously when an irate mother indignantly demanded that her son be put to work because she couldn't stand him around the house any longer. He was impudent and irreverent! What did she mean by that? He had taken the family Bible, his grandmother's false teeth, and an elastic, and had made a rat trap out of them!

Here was someone touched by destiny. He subsequently became the chief engineer. The dreadful sting of talent often announces itself in annoying ways because, as we said at the outset, anyone with creative ability is never satisfied to leave things as they are; anyone with creative ability has a startling capacity for perceiving the unusual.

What a boy has been doing with his spare time during the years in school or college is a far better clue to what sort of stuff he has in him than the first five years in industry, because during these years he has had more opportunity to run free—to express his real self—than later when he is confined by the necessity of earning a living. So look to the past if you would see the future.

How valid are grades in diagnosing a man's ability? To answer this question a study was made of the living Technology men[1] who have achieved the distinction of being cataloged in "Who's Who in America," "Who's Who in Engineering," or "American Men of Science." Table 1 classifies their relative academic standing from the first to the tenth decile of the class, i.e., from top to bottom.

TABLE 1 RELATIVE ACADEMIC STANDING BY DECILES

	"Who's Who in America"		"Who's Who in Engineering"		"American Men of Science"	
Decile	No.	Per cent	No.	Per cent	No.	Per cent
1	68	15.3	128	16.1	123	23.8
2	60	13.5	108	13.6	85	16.5
3	45	10.2	87	10.9	67	13.0
4	49	11.1	93	11.7	62	12.0
5	26	5.9	63	7.9	39	7.6
6	19	4.3	45	5.7	26	5.1
7	23	5.2	46	5.8	23	4.5
8	30	6.8	54	6.8	23	4.5
9	26	5.9	53	6.7	23	4.5
10	96	21.8	118	14.8	44	8.5
Total	442	100	795	100	515	100

There will be a good deal of disagreement as to what these figures mean. More men whose names are found in "Who's Who in America" came from the bottom of their classes than from any other decile. Is this because their creative ability was not scientific? Were they ducks, unable to scratch successfully in the engineering barnyard, who eventually distin-

[1] There are 497 men who appear in two of these volumes, and 91 whose names are in all three.

guished themselves by flying off to some pond? Before answering too quickly, note that even among the men of science there are more from the bottom decile than from any of the fifth to the ninth deciles inclusive, i.e., half the entire class. Is a poor school record sometimes the very result of creative ability? May not a restless appetite for reaching out toward the far horizon make the predigested food of most college courses somewhat nauseating? Certainly these men didn't achieve distinction just because they were at the bottom of the class.

One conclusion seems certain; mediocrity is always mediocre.

Diagnostic situations that are valid always see the man as a whole. Moreover, the skillful diagnostician will always analyze any part from the point of view of its relationship to the whole. For as Gen. J. C. Smuts pointed out some years ago in his scholarly address to the British Association for the Advancement of Science, things are not the sum of their parts but the organization of their parts.

A competent interviewer will put the applicant into diagnostic situations that are valid because the applicant is allowed to behave naturally and as a whole personality—not artificially confined.

When he was in charge of the personnel office of the Dennison Manufacturing Co., Elliott Smith developed several such approaches. He would show the interviewee the top of a box which had been covered with Christmas paper. "Look carefully at this box top with me. The box is four inches square and one inch deep. The paper overlaps the corners and the bottom edges by a quarter of an inch. I want you to draw for me what that paper looked like before it was pasted onto the box. Your drawing will show solid lines where the paper was cut, dotted lines where it was folded. Omit all dimensions and no erasures are allowed."

The applicant is now completely on his own. Does he stop to think before going into action? Does he have three-dimensional visualization? Is his work neat? Can he follow directions? Does he think through to the end, which will include a careful analysis of how the paper is to be most efficiently put onto the box?

When the drawing is completed, argue his answer with him. Why didn't he do it this way? If he has really thought, he will give reasons for doing it his way. If he has been only guessing, the diagnostic situation will reveal it at once. What he thinks is not so important as how he thinks.

Does he have creative engineering ability? Ask him how to put the paper onto the box by machinery. Then ask him why you wouldn't do it that way.

What is his first reaction when running free? Does he have a pretentious perch on reality or does he go whooping into analysis? And if analysis, then is it the kind of analysis that produces creative ideas in research, development, organization, sales, or finance? Nothing is so wrong as creative ideas in the wrong place, as the father discovered who went to Florida for the winter leaving his printing establishment in the hands of a development-minded son. When he returned in the spring father found the business entirely ruined and the presses in various stages of being taken apart.

"But father," the boy protested in a stuttering explanation as the emotional seismographs began to record the old man's tremors, "I can make those presses work better."

Creative ability in research is badly out of place where managerial ability is the prime necessity. What kind of creative ability are you looking for, and what sort of diagnostic situation will identify it?

Anyone who is going to do a good job at this must take a good deal of time to do a lot of penetrative thinking. This is particularly true if he is just beginning. If he is so unfortunate as to have long-run habits of poor method, his reform is almost impossible, though repentance may be relatively easy.

CONCLUSIONS

The selection of men with creative ability depends upon knowing what the qualities of these men are and being able to identify them. Such identification is often difficult even after long acquaintance. It is even more so in an interview.

Good interviewing depends largely upon the skill of the interviewer in knowing how to explore his areas; to collect and evaluate the evidence, particularly the circumstantial evidence; to put the applicant at ease so he can act naturally; and to devise diagnostic situations that are a valid test for the particular kind of creative ability desired.

Good method in selecting men with creative ability takes time, both in the development of the art and in its execution. But good selection is worth all the time that it takes.

The Future *of* Power Use *in the* Pacific Northwest

(Continued from page 664)

The same importance attaches to power in many similar heavy chemical and electrometallurgical industries. The recent development of the new and cheaper processes for the production of magnesium metal and metallic manganese of high purity shows definite possibilities as power markets owing to large local deposits of both manganese and magnesite and very great prospects for increased use of these metals. Magnesium metal at 30 cents per lb is one thing, but at half that price or less it is likely to become of very great industrial and commercial importance. Similar demands for power in the electrometallurgical and mining industries are indicated by the vast development at Trail, British Columbia, where power is used for a multitude of purposes, including a large electrolytic production of zinc.

The rapid development of new methods in metallurgy are sure to contribute largely in the development of the Northwest. New methods of handling low-grade iron ores recently announced are quite likely to insure the development of iron and steel production in the Northwest region, and it seems only a matter of time until methods will be perfected whereby alumina can be segregated from the enormous clay deposits available, and which, with the large power facilities in this district should multiply the production of aluminum. Many other possibilities of this and other sorts, some of which are yet only unknowns, are sure to find their place.

At the present time the Northwest is furnishing a very large amount of the wood pulp used in the rayon industry. It is quite possible that some of the rapid developments in this field may find their best opportunity in the Northwest. In view of these considerations, it does not seem impossible that, within the next generation, the vast power resources of the Northwest may become its major asset through application to the development of the latent physical resources of the region.

ENCOURAGING CREATIVE ABILITY

By A. R. STEVENSON, JR., and J. E. RYAN

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THE function of a creative mechanical designer is similar in many ways, to that of a mother in giving birth to a child. An idea is conceived and nurtured in his mind; then, when ready for delivery, it is born on paper. Like doctors and midwives, the expert analytical engineers and manufacturing men may assist the designer in bringing forth a safe and sound design, but it cannot be denied that the designer, like the mother, is the principal figure in the development of any new idea.

It is interesting to note the change in emphasis that has been placed upon this phase of engineering at various times. During the industrial revolution and for some years thereafter invention was in the ascendancy. Men were so busy conjuring up new ways to apply mechanical power to human tasks, however, that little attention was given to the "efficiency" of a design. It was quite an achievement to get something that worked at all. If the designer felt that a machine part could possibly fail in service, he simply added more material, since prospective buyers were prepared to pay almost any price to get the new mechanical servants. As a result, machines of that era were ingenious but, for the most part, cumbersome devices.

Meanwhile, the physicists and mathematicians of the nineteenth century began to make startling discoveries in the fields of mechanics and thermodynamics. Gradually, these new principles were utilized by engineers in designing apparatus and many refinements were achieved by the increasing use of mathematical analysis in enginering.

Toward the close of the last century, the so-called mass-production era began. Not only were great strides made in organizing men and machines to turn out mechanical products on a large scale, but the same philosophy eventually permeated the educational system. College courses began to dwell more and more on usable results rather than on the methods by which such results were obtained. Fortunately, there has been a noticeable trend toward more fundamental training in recent years, with industrial firms sharing responsibility with the colleges.[1]

Yet, while all this development of improved manufacturing methods and more fundamental engineering analysis was going on, the creative, inventive phases of mechanical engineering were, for the most part, being allowed to shift for themselves in that the engineering colleges placed little emphasis upon them. To be sure, these orphans did not do at all badly under the circumstances, but it must be admitted that whatever stimulus has been given to this creative ability in undergraduate days has come informally through student-professor relationship.

More often than not, the really ingenious designers of today are men who have come up through the shop and drafting room, possessing a wealth of first-hand experience with mechanisms and manufacturing processes. Their minds can synthesize bold, original designs, free from the necessity of analyzing everything mathematically before venturing to put it on paper. This does not mean, of course, that the more advanced methods of analysis which we are teaching to our young engineers are futile; on the contrary, they are needed more and more, but in their proper place. The majority of new ideas are not analyzed into existence; instead they are synthesized from sound qualitative concepts, using an active imagination as a catalyst.

Mechanical design is an art perhaps even more than it is a science. Like a musical composer who must be thoroughly grounded in harmony and the principles of composition, the designer must know his physics and mechanics. Just as a painter must learn how to prepare a canvas and mix colors, the designer must understand the properties of materials which he specifies. But who has composed great music or painted great pictures with nothing more than these technical skills at his command? So it is with mechanical design; the essential attribute is a trained, imaginative mind.

DEVELOPING TOMORROW'S DESIGNERS

What, then, can be done to foster design ability in young engineers? Most people concede that the creative flair must be born in a man but it remains for schools and colleges to detect this undeveloped ability and give it proper exercise and encouragement. As stated before, neither of these functions has been given sufficient attention in engineering colleges, and whatever ingenuity a man may possess is often so deeply buried under a four-year layer of erudition that it takes years for it to reappear, if it ever does. To make matters worse, the lack of emphasis on the scope and importance of design engineering during undergraduate years has caused many college students to look upon a designer as a routine draftsman. If this misconception be allowed to continue, the really good men will shy away from design still more and none but the mediocre ones will be left to carry on the vital work.

Discovering creative ability and originality is not an easy task. Whereas ability in mathematical analysis can be measured quite accurately by a conventional examination, a satisfactory index of creative ability is much more difficult to obtain. Several good aptitude tests in mechanisms and spatial visualization have been devised but the authors believe that they are only partial measures. Boyhood hobbies and interests, when honestly expressed and appraised, are one of the best guides. For example, nearly every boy has built a model airplane at some time but unless he has eventually cut loose from standard plans to try a brain child of his own, he is probably not a designer at heart. Handicraft skill is sometimes mistaken for a sure indication of design ability. Such skill enables the right men to profit by first-hand experience with the working properties of engineering materials, but by itself it is neither a sure nor sufficient indication. Second only to creative hobbies as an indicator is familiarity with the construction and opera-

[1] "An Advanced Course in Engineering," by A. R. Stevenson, Jr., and Alan Howard, *Electrical Engineering*, March, 1935, pp. 265–268.

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tion of a variety of machines. This is based on the theory that a man naturally becomes familiar with the things that are vitally interesting to him. How valid these various measures are can be known only by observation of the men thus selected over a long period of time.

The engineering colleges can do much to encourage the creative ability of their students by allowing them greater latitude in the selection and furtherance of machine-design-course projects. Also, arrangements should be made to permit at least the more promising students to construct these or other projects of their own in the college shops. Of course, all of this requires much more faculty supervision and guidance, but it is one of the most fruitful investments of time and energy that a true teacher can make.

It is generally conceded that each industry must continue the education of its young engineers along its own specialized lines, whether formally or informally. If creative ingenuity itself cannot be taught directly, at least the embryonic designer can be thoroughly familiarized with up-to-date engineering materials and manufacturing methods. With these building blocks, his imagination can then erect proper mental concepts of machinery which will not only operate but will be efficient and inexpensive to build.

A TRAINING PROGRAM IN INDUSTRY

In 1937 the General Electric Company founded its mechanical-design course to give such training to a small selected group of young engineers after their first year of employment. These are drawn from electrical- as well as mechanical-engineering graduates, the prime requisite being a quality of mind rather than previous training.

The training program consists of (1) actual experience in design through a series of varied assignments, and (2) instruction in materials, manufacturing processes, and engineering analysis in the classroom and factory.

Over a period of approximately a year, each man works in three or four departments in turn, one of which is usually a developmental laboratory. In each place an outstanding designer or developmental engineer supervises his work and takes special care to develop his abilities through discussions and personal example as a master mechanic would guide his apprentice. So far as possible, the young engineer is given practically complete responsibility for the design of an entire device. The most beneficial assignments are those in which his projects are short and varied, requiring more ingenuity than preliminary knowledge. This enables him to see his job through to a successful conclusion and gain the early confidence so essential to a productive career.

Four or five times a year the designers in charge of the assignments gather at a conference to discuss the progress of the men on the course, new candidates, and various aspects of the educational work. Through discussion, the strong and weak points of each student engineer are brought out so that those having contact with him may more effectively utilize the strong qualities while strengthening the undeveloped ones. Much credit for the success of this course must be given to the hearty support and intelligent guidance offered by this informal committee.

Classroom and factory instruction is given to the mechanical-design-course group four hours each week. The subjects covered are shown in Table 1.

Because the groundwork has been laid for the subjects of groups 1 and 2 in a course which nearly all mechanical-engineering graduates take during their first year of employment, the design-course men spend most of the time allotted to these topics making inspection trips through the shops. There experienced factory men describe and demonstrate the various fabrication methods, pointing out their respective advantages and limitations. To drive home the observations thus made, design problems are given which require an accurate visualization of the manufacturing methods from start to finish.

TABLE 1 CURRICULUM OF THE MECHANICAL-DESIGN COURSE

Group 1	*Materials*	
	A Metallography	Covered principally in preliminary one-year course
	B Ferrous metals	
	C Nonferrous metals	
	D Heat-treatment	
	E Plastics	
Group 2	*Manufacturing Processes*	
	A Patternmaking and molding	Taught through inspection trips supplementing class work in preliminary course
	B Die casting	
	C Forging and cold heading	
	D Extrusion	
	E Welding	
	1 Resistance	
	2 Nonpressure	
	F Machining	
	G Punch and die work	
	H Brazing	
Group 3	*Technical Subjects*	
	A Elasticity	
	1 General equations	
	2 Beams	
	(*a*) Simple	
	(*b*) Statically indeterminate	
	3 Torsion	
	4 Plates	
	5 Press and shrink fits	
	6 Energy methods	
	7 Stress concentration; photoelasticity	
	8 Introduction to plasticity	
	B Dynamics	
	1 General	
	2 Vibration and balancing	
	3 Critical speeds	
	C Elementary differential equations	
Group 4	*Graphics*	
	A Descriptive geometry	
	B Sketching	
	C Drafting practice	

The work in mechanics contained in group 3 is partly a review of undergraduate work and partly more advanced material. Differential equations are covered only to the extent required for the more common engineering problems. All in all, the object in treating these subjects is to round out technically the men whose chief strength is in their creative intuitive abilities rather than to try to make analytical giants out of them.

Descriptive geometry and sketching are included in group 4 to give practice in the visualization and representation of ideas. Sketching is practiced throughout the course in the belief that it not only facilitates the representation of ideas but stimulates their conception as well.

During the last third of the course, each man works on one or more inventive design projects of his own selection as part of the homework and those who wish to construct working samples of their designs in their spare time have a well-equipped machine shop in the local technical high school at their disposal. The unlimited choice of projects allows each individual to gravitate toward the type of work he enjoys most. These projects, therefore, are good indicators of the direction as well as the magnitude of a man's ability.

A total of about twenty-five young men have gone through this course since its inception and are now actively engaged in design and related activities. Some others who began the course were shifted to other kinds of work when they appeared to lack the necessary originality. The percentage of such men has never been large. Nevertheless, it does mean that there is still room for improvement in the technique of selection.

The ECONOMICS *of* WAR[1]

By RALPH E. FREEMAN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

WHEN a nation passes from peace into war, or into rapid preparation for war, there is added to the ordinary demands of the population the demands of its armed forces. Two major questions arise. First is the question as to the redistribution of our productive resources. What peacetime industries should be curtailed? What war industries should be expanded? Second, is the question as to the means which should be adopted to transfer economic resources out of the peacetime into the wartime industries. In practice these questions cannot be answered separately. The character of the transfer to be made will influence the method used, and the method of transfer which is adopted will help to determine the kinds of resources which are actually shifted.

In considering the first question we should bear in mind that not all the increased output of war goods need be made at the expense of a decreased output of ordinary goods. As far as labor is concerned, there may be unemployed persons who can be absorbed into the army or into industry and agriculture; man power may be increased by the employment of women, youngsters, and elderly men; hours of work may be extended. As far as plant and equipment are concerned, there may be some unused plant capacity which can be put into operation; it may be possible to utilize existing plant more intensively by working it 24 hours in three shifts. By such means the total output of the nation may be expanded so that some of the demands of the armed forces can be met without sacrificing ordinary goods.

But the additional productive power so obtained will not be adequate to meet the increased demands of war. The activity of many peacetime industries must be curtailed and their resources released for the expansion of wartime industries. In general it may be said that curtailment should be effected in those industries whose products are not in urgent demand, and that the industries in which expansion takes place should be determined by the requirements of the armed forces. To decide what peacetime goods can most easily be dispensed with and what military materials and supplies should be produced and the relative quantities needed in time of war is not a simple task. And the mobilization of resources is complicated by the fact that many of the resources released from making the less essential peacetime goods will not be adaptable to the production of munitions for the Army and Navy.

Consider some of the difficulties involved in the transfer of labor. The men deprived of work because of the contraction of a peacetime industry may not have the skill necessary to enter the wartime industry. The increase in the output of munitions must, therefore, be held up until workers can be trained; or the requisite man power will have to be recruited from peacetime industries producing goods whose output cannot be diminished without hardship to the community. Moreover, if the expanding and contracting industries are located in different parts of the country, there will be a lack of housing facilities in one region and a surplus in the other. How are the new living accommodations to be provided? What will happen in the community where plants are shut down and workers emigrate?

The allocation of sufficient labor to the industrial pursuit of war does not solve the problem. Men must have material to work on, machinery to work with, fuel and power and all the other essentials of production. To withdraw plant and equipment from the production of peacetime goods and to utilize the facilities for the making of wartime goods may in some instances be fairly easy. The shoe industry, for example, can supply boots and shoes for the Army without difficulty by using the equipment formerly employed in making shoes for civilians. The automobile industry can make airplane engines; the agricultural-machinery industry can make tanks. But in other instances great difficulties may be encountered.

When important resources are obtained from abroad, the expansion of war industries may be impeded by interruptions in the normal flow of goods across the borders. In the case of strategic materials, curtailment of peacetime use may have to be very drastic. New industries producing substitutes may have to be created and strenuous effort put forth to reclaim these materials wherever possible. Interruptions of foreign trade are not limited to trade with the enemy. All international trade is dislocated and accustomed foreign sources of supplies may dwindle even if their sources are in allied or neutral countries.

Then there is the question of how the necessary readjustments are to be effected. In normal times economic adjustment is left to the free play of a system based on private property, individual initiative, and free competition. To be sure this free play is, and always has been, somewhat restricted by government action as well as by frictions, inequalities, and monopolistic tendencies. But in spite of these limitations, we normally rely on the mechanism of prices to take care of most of our peacetime adjustments. When the community wants more goods of a certain type the price rises, profits increase, production expands, and resources are attracted from other industries. When the community wants less of other goods of a certain type, demand shrinks, the price drops, losses appear, production contracts, and resources are driven out into other industries. Those industries whose products are in greater demand attract workers by offering higher wages. Those industries whose products are in less demand are unable to pay sufficient wages to hold their workers. The same method is in operation in distributing capital. Profitable industries enjoying increased favor with consumers are able to outbid the unprofitable industries which have suffered a decline in consumer favor. Capital is shifted in response to changes in the relative rates of return on investments.

The same mechanism of adjustment is relied upon to some degree in time of war. The production of certain less essential

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

The present article "The Economics of War" is submitted not as a review but for the purpose of introducing the reader to some of the more important problems raised in several books dealing with war economics, now appearing on the market.

"War in Our Times," by H. Speier and A. Kähler (W. W. Norton, New York, N. Y., 1939), consists of contributions by the graduate faculty of The New School for Social Research, and is concerned mainly with the economic aspects of modern war.

"War in the Twentieth Century (Random House, New York, N. Y.) is a symposium edited by Willard Waller; the reader is referred to the section entitled "Economy in War Time."

peacetime goods is cut down by curtailing the flow of purchasing power toward those goods. This curtailment may be effected in various ways. Severe taxation is one way. Heavy income taxes reduce the income available for spending, and with smaller incomes people tend to buy fewer luxuries. Or taxation may be imposed on the luxuries themselves making them more expensive and inducing people to cut down their purchases. The government then uses the money obtained from these taxes to purchase wartime goods. Thus the demand for peacetime goods is reduced and the demand for wartime goods is increased. Prices of the former fall and of the latter rise; and resources are shifted in response to these price changes.

Consumption and production of unessential peacetime goods may be reduced also by the community subscribing to war loans. The money so subscribed is transferred to the government instead of being spent on consumer goods. The output of these goods is curtailed. The government directs this money into wartime goods; the output of these goods is increased.

Similar results may be achieved without taking money directly from the people. This is the method of inflation. The shift of resources is effected by raising the price level. When the price level rises the purchasing power of the dollar falls and the people cannot buy as much as before. They have to curtail their consumption. But the government has more to spend. Though the purchasing power of the government's dollar is also less, it has additional dollars obtained by creating additional money or credit. Thus inflation is effective as a concealed taxation, a taxation that is proportional to income not exempting even the poorest.

In war, however, sole reliance cannot be placed upon the price system as a method of adjustment. By taking away part of the income of the community the total volume of consumer spending can be curtailed and the production of consumers' goods reduced. But there is no assurance that these reductions will correspond to war requirements. If the facilities required to produce one commodity are more adaptable than another to the production of war goods, it is more important to reduce the output of the former than that of the latter. There must therefore be direct intervention by the government.

In times of peace, a shortage of one of the necessities of life will produce a rise of its price and the producers enjoying greater profits will increase the output and remove the shortage. In war, the price change may not operate in this fashion. The shortage may be caused by a disruption of the channels of supply which cannot be remedied. In this case the high price merely restricts the use of the commodity to the wealthier classes. If the commodity is a vital necessity, such a restriction cannot be tolerated. There must be price fixing by government; a system of rationing must be introduced.

A similar situation is likely to exist in the field of producers' goods—the materials and equipment for producing shells, guns, warplanes, and warships. In peacetime, shortages of materials are relieved partly through expanded output by the producers of the materials who respond to the price increases, and partly through the effect of high prices in discouraging the use of the scarce materials. But in time of war, the free increase of prices and profits cannot serve the purpose of encouraging the output of the scarce materials and discouraging their use. The problem at such times is not to discourage the use of the materials but to satisfy the government's urgent need. Control of the prices of strategic materials is, therefore, a logical element of a war economy.

As in the case of consumers' goods, control of the prices of producers' goods requires a system of rationing to insure that the goods are devoted to their most important uses. A priority system must be developed. An agency must be set up to insure that preference is given to the more urgent requirements over those that are less urgent. During the last war such agencies were established in all belligerent countries including the United States. And in the war of 1939 the belligerents started out with priority systems prepared in advance. Priority affects not only manufacturing and delivery schedules, it involves also raw materials, fuel, and other supplies as well as transportation service.[2]

The control has to be extended also, as already suggested, into the supply of labor. This begins with the selection of the fighting force. Since the highly technical character of many types of war material makes many trained workers more valuable in the factory than on the field, a selective system of enrollment must be used. The government must also assist in the necessary transference of labor from peacetime industries into wartime industries. This transference may be stimulated through the price system, by wages rising in the war industries and falling in the peace industries, thus making it profitable for workers to shift of their own accord. But this method is too slow to be entirely satisfactory. Employment agencies must be coordinated with the government's agency in control of production. Transplantation of labor is facilitated by large-scale construction of housing facilities. War orders must be allocated with reference to the distribution of the labor supply. Plants manufacturing unessential goods must be forced to close if they employ workers who can be transferred to a war industry. Training of new skilled workers must be undertaken by the government, or private industry be compelled or induced to train new workers in their own plants. In fact, in some instances, the government may go so far as to introduce a general conscription of labor.

It is apparent that the control which should be exercised over the economic activities of a nation in time of war is almost the equivalent of a centralized management of industry. "War is no longer simply a battle between armed forces on the field—it is a struggle in which each side strives to bring to bear against the enemy the coordinated power of every individual and every material resource at its command. The conflict extends from the soldier in the front line to the citizen in the remotest hamlet in the rear."[3] In waging such a war the totalitarian nations have an advantage over the democracies. The totalitarian nations have centralized economic control at all times and, since a preparedness economy is similar to a war economy, these nations are likely to be better prepared.

Not until hostilities are imminent or have actually begun do the democracies adopt anything like the centralized system that is demanded by industrial mobilization for war. Adherence to the ideals of private property and freedom of competition—and political considerations—make them reluctant to abridge their economic liberties until the very last moment. A democracy, therefore, is likely to be relatively unprepared for war and may be crushed by the swift onslaught of its totalitarian adversary. Even at this late hour our own industrial-mobilization plan—incomplete and sketchy though it is—has not been invoked. Some people insist that the present emergency requires the invocation of this plan and that the necessary legislation should be passed to bring it into operation.[4] But whether or not such action is taken, the requirements of industrial mobilization for war point clearly to the necessity for coordination of effort under a central planning authority.

[2] "Industrial Mobilization Plan Revision of 1939." (7th Congress, 2nd Session, Senate Document No. 134.) United States Government Printing Office, Washington, 1939. This plan sets forth the priority system to be introduced into the United States in time of war.

[3] Ibid, p. 1.

[4] This question is discussed in a recent book by H. J. Tobin and P. W. Bidwell, "Mobilizing Civilian America," N. Y. Council on Foreign Relations, 1940.

VOLUMETER RESEARCH

An Interim Report of the A.S.M.E. Special Research Committee on Fluid Meters

By EDGAR E. AMBROSIUS[1] and HOWARD S. BEAN[2]

SOON after its formation in 1916 the A.S.M.E. Special Research Committee on Fluid Meters made plans for a study of volumetric-type meters. Before any experimental work could be arranged the committee was obliged to lay these plans aside in order to give its full attention to two other matters. The first was the assembling and publishing of information then available on fluid meters as was done in the first and second editions of Part 1 of the committee's report "Fluid Meters, Their Theory and Application." The second was an extensive study of head meters. Part of this study, namely, that on square-edged orifices, was conducted in cooperation with a similar committee of the American Gas Association. Another part, on flow nozzles, was arranged by this committee and carried out with assistance from several laboratories. This study of flow nozzles is nearly completed, and a report on it is being prepared.

TESTS OF VOLUMETERS PLANNED

In returning to the study of volumeters the committee has decided to give attention first to those meters which are designed more or less specifically for use in the oil industry. One reason for this is that the use of meters in all phases of the oil industry has been steadily increasing for several years; a second reason is that there has been more or less discussion in the legislatures of several states about laws to require the use of meters in all gathering lines and pipe lines. The committee believed that a thorough, unbiased study of these meters should develop much information of real value at this time to the meter manufacturers, the meter users, and the general public through those agencies which are charged with the supervision of the measurement of petroleum products in retail and wholesale trade.

The facilities immediately available made it convenient to start with meters particularly suited for use in oil-well lines, in transmission lines, and in refineries. Next, a study will be made of meters used in connection with retail sales of such products as fuel oil, gasoline, and liquefied petroleum gases. Later the committee will probably give attention to volumeters designed more specifically for other fluids such as water, chemicals, and gases.

The first step in the present program is the careful testing of a group of representative meters for use in 2-in. and 4-in. lines. These tests will be made at the University of Oklahoma (Fig. 1), and with the equipment there available it will be possible to vary the rate of flow through any meter from about 5 to 125 per cent of its rated capacity, with a possible maximum rate of about 450 gpm. A record of the pressure drop across the meter will, of course, be a part of the test data. These tests will be made with refined oil which may be considered stable and free from wax and paraffin. At least two oils with different viscosity indexes will be used, and by heating, the viscosities of the oils can be varied over a moderately wide range, and thus information will be obtained on viscosity and temperature effects.

As soon as several meters have been completely tested in this manner in the laboratory they will be placed in actual field service at a convenient location in the Oklahoma City field. At regular intervals these meters will be returned to the laboratory to be retested while other meters are installed in their places. In this way data will be obtained on the rate of wear. In addition there will be a field proving tank and the gagings of the field tanks with which the meters may be compared.

Another part of the program is a study of the effects of differences in installations and operating conditions. This will involve a study of settling chambers, separators, and the like. As yet, no detailed plans for this part of the program have been made, other than to arrange that it will be carried on under the

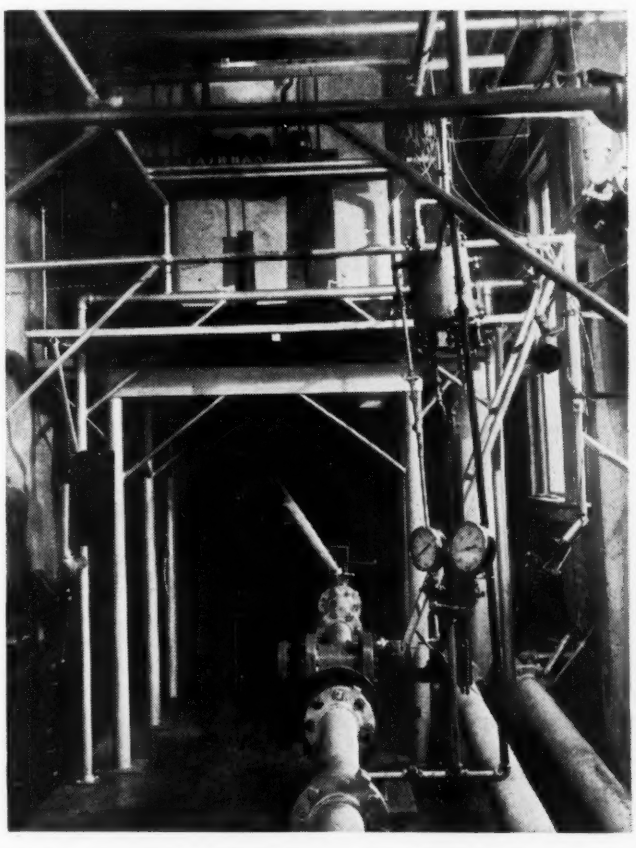

FIG. 1 VOLUMETER TESTING EQUIPMENT AT THE UNIVERSITY OF OKLAHOMA

(Meter readings are taken "on the run" with the small electrically operated camera on the bracket at extreme right.)

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[2] Senior Physicist, National Bureau of Standards, Washington, D. C., and member A.S.M.E. Special Research Committee on Fluid Meters.

immediate supervision of the Bureau of Mines Station at Bartlesville, Okla.

Throughout the course of this program the committee expects to publish reports of its work as the data are accumulated. In order that the same name or descriptive terminology may be used throughout these reports it will be well to give here an explanation of the operating features which will form the basis for the names used. The authors wish to have it understood that these names are suggested primarily for the committee's convenience, and that no manufacturer need feel obliged to use these names in describing his meter.

COMMITTEE SELECTS TERMINOLOGY

In the fourth edition of Part 1 of the committee's report, "Fluid Meters, Their Theory and Application," there is given a general classification of fluid meters. Under that classification all of the meters to be used in the present study are included in the following three classes—weighing, volumetric, and velocity. The first two classes are true "quantity meters," the distinctive feature of these meters being that *all* of the fluid to be metered passes through the primary element in successive and more or less completely isolated quantities. The velocity meters belong to the rate-meter division which includes all meters in which the fluid flows through the primary element in a continuous stream, and the registration of these meters is derived from some effect of the moving stream. The meters included in each of these three classes may be subdivided further according to the type of primary element used, as named and described in what follows. The reason for including weighing and velocity meters in this research on volumeters without some qualification in the title is that generally the index used with these meters is essentially the same as that of the volumetric meters and is arranged to indicate in terms of volume (or weight) units.

The following descriptions and illustrations of the several "type" names of meters are not intended to represent the product of any particular meter manufacturer, but are given to aid the reader in forming a mental picture of the distinctive operating features which the name is intended to convey. Furthermore, the authors are not concerned here with the materials of which a meter may be constructed but only with the metering principles utilized; for, obviously, while the materials suitable in a meter for oils would probably not be suitable for an acid, yet the same metering principle can be used for both liquids.

WEIGHING METERS

Tilting-Trap Type. Under weighing meters the only type that need be considered is the "tilting trap," diagrammatically illustrated by Fig. 2. The two tanks A and A' are supported on the pivots (knife-edges) K and K' and counterbalanced by the weights W and W'. The liquid to be metered runs through the diverting trough into one of the tanks (as shown here, A'). When the weight of the liquid in the tank becomes sufficient to tip the tank on its pivot to the position in which A is shown, liquid begins to discharge through the siphon S', and the diverting trough is tipped about its axis C, thus diverting the incoming liquid into the other tank A, which meanwhile has returned to an upright position. When a portion of the liquid has drained out of tank A' the counterweight causes the tank to return to its original position, but the siphon will continue to flow until the tank is emptied to the level of the edge of the siphon tube. As the second tank is filled it tilts, shifting the diverting trough back to the position shown in the diagram.

There is a variation of this design in which the two tanks are mounted on a common shaft in such a way that the tilting of one tank brings the other into position for filling. In this design the siphon may be eliminated.

VOLUMETRIC METERS

Meters of the volumetric class may be subdivided into the following types: nutating disk, reciprocating piston (or simply piston), planetary piston, sliding or rotating vanes, and gear or lobed impeller.

Nutating-Disk Meter. Fig. 3 is a cutaway view illustrating the interior of a nutating-disk meter. The top and bottom surfaces of the measuring chamber are conical, extending inward, and the chamber side wall is spherical. The movable element is the disk mounted on the central ball from the top of which a pole or shaft, perpendicular to the disk, extends through the top of the measuring chamber. This shaft is held in an inclined position by a cam or roller so that the disk is in contact with the bottom of the measuring chamber along a radial element on one side of the ball, and in contact with the top of the measuring chamber in the same radial plane on the other side of the ball. To prevent the disk from rotating there is a radial slot in the disk which engages a radial partition as shown in Fig. 4. The inlet and outlet ports are in the side wall of the case, adjacent to, and on opposite sides of, the radial partition. Liquid enters the measuring chamber alternately above and then below the disk and must pass entirely around the conical measuring chamber to the outlet port. This movement of the liquid around the measuring chamber first above and then below the disk produces a nutating motion of the disk (nodding in a circular path without revolving about its own axis). As the disk nutates the top of the shaft moves in a circular path, and by engaging with a crank on a shaft from the index, operates the meter index.

Between different makes of nutating-disk meters there will be minor variations in design. For example, instead of a flat disk as shown in Figs. 3 and 4, some meters have a coned disk. In such a case the top and bottom will not have the same cone angle.

Another feature of these meters is that the relation between the measuring-chamber displacement and the meter registration can be changed by changing one or more gears in the index gear train, or by a small adjustable by-pass[3] around the measuring chamber.

Piston Meters, Reciprocating Type. Piston meters of the reciprocating type are essentially reciprocating-piston engines, the important difference being that whereas the engine is designed to take as much energy as possible from the fluid passing through it, the meter extracts only enough to overcome the resistance offered by the pistons, valves, and index. Fig. 5 shows a cross section through a meter of this type. The operating cycle of such a meter can readily be followed from the figure.

Numerous variations will be found in the designs of reciprocating-piston meters. For example, the valves may be built integral with the piston. In another case, only one cylinder and one piston are used with an auxiliary piston to assist in operating the valve. Again, a number of cylinders may be placed radially and the pistons connected through connecting rods to a common crankshaft, as in radial-cylinder aircraft engines. A meter of this kind will probably have a single rotary valve driven from the crankshaft. Another variation is that in which a number of parallel pistons are located in a circle and their pistons are connected to a wobble plate which has a motion similar to that of the disk of a nutating-disk meter.

In reciprocating-piston meters, sealing rings of metal, composition, or leather may be used to reduce, if not practically to

[3] Many fluid-metering authorities consider the use of a by-pass as very objectionable because its passage area is so susceptible to change by the lodgment of foreign particles carried by the fluid. None of the meters being used in the committee's program is equipped with a by-pass.

eliminate, any slippage past the piston. Another method is to use a longer piston with several small circumferential grooves to reduce slippage by capillary sealing.

In some designs adjustment of the capacity per cycle may be made by regulating the stroke of one or more of the pistons, as by the adjustable stops in the cylinder heads shown in Fig. 5. In other designs this method of adjustment cannot be used, and

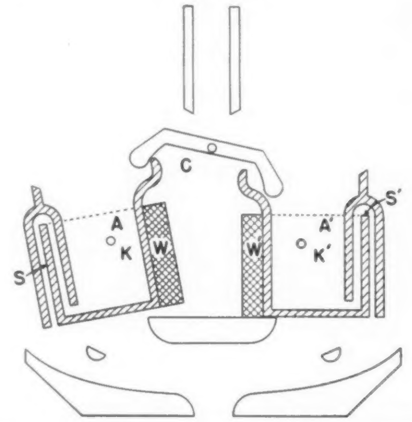


FIG. 2 TILTING-TRAP TYPE OF WEIGHT METER

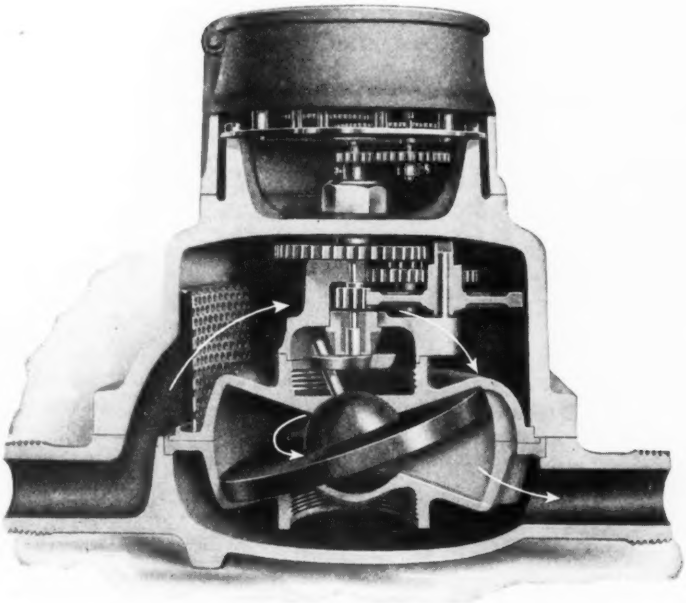


FIG. 3 INTERIOR OF A NUTATING-DISK METER

if there is to be any adjustment of the calibration it may be necessary to change the gears in the index gear train or to use a by-pass.

Planetary[4]*-Piston Meters.* In planetary-piston meters the piston and cylinder are the same length (except for a small operating clearance), but the diameter of the piston is much less than that of the cylinder. Moreover, the piston is hollow and the cylinder chamber is annular, as shown in Fig. 6. Between the outer and inner walls of the cylinder there is a radial partition *A*, and in the side wall of the piston there is a slot only wide enough to fit the partition without binding. This partition and slot prevent rotation of the piston. Mounted in the center of one cylinder head is the post *B*, and in the head of the piston is the post *C*. The outer and inner diameters of the hollow piston, the outer and inner diameters of the annular cylinder, and the inner diameter of the inner cylinder wall and the diameters of posts *B* and *C* are all so related that the outer surface of the piston is always in contact with the inner surface of the outer cylinder wall and the inner surface of the piston is always in contact with the outer surface of the inner cylinder wall. Post *C* is designed to have only easy sliding clearance between post *B* and the inner surface of the inner cylinder wall.

The motion of the piston and its action as a valve as well as a piston are more easily explained by reference to Fig. 6. The irregular areas *D* and *E* represent the inlet and outlet ports,

FIG. 4 MEASURING CHAMBER OF A NUTATING-DISK METER

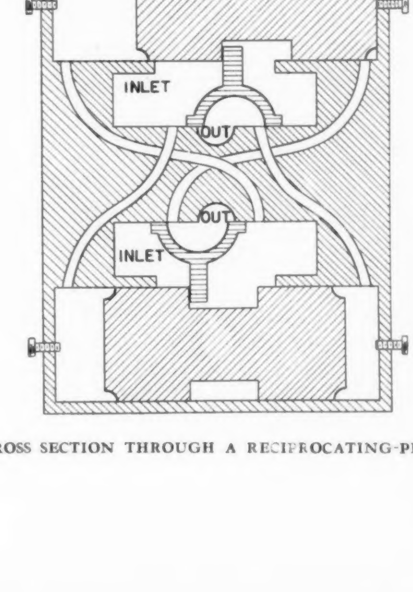


FIG. 5 CROSS SECTION THROUGH A RECIPROCATING-PISTON METER

[4] The appropriateness of this name is based on the similarity between the motion of the meter piston and the motion of the middle gear in an epicyclic gear train to which the name "planetary" is commonly applied. The names "rotary" and "oscillating" have been used, but the piston does not rotate, i.e., turn its own axis, nor does it as a whole revolve about some other axis. "Oscillating" is applicable by the definition (Standard Dictionary) "varying between fixed limits which are reached alternately," but the authors' objection to this name is that the term usually conveys the idea of a fixed center about which the swinging or vibrating takes place.

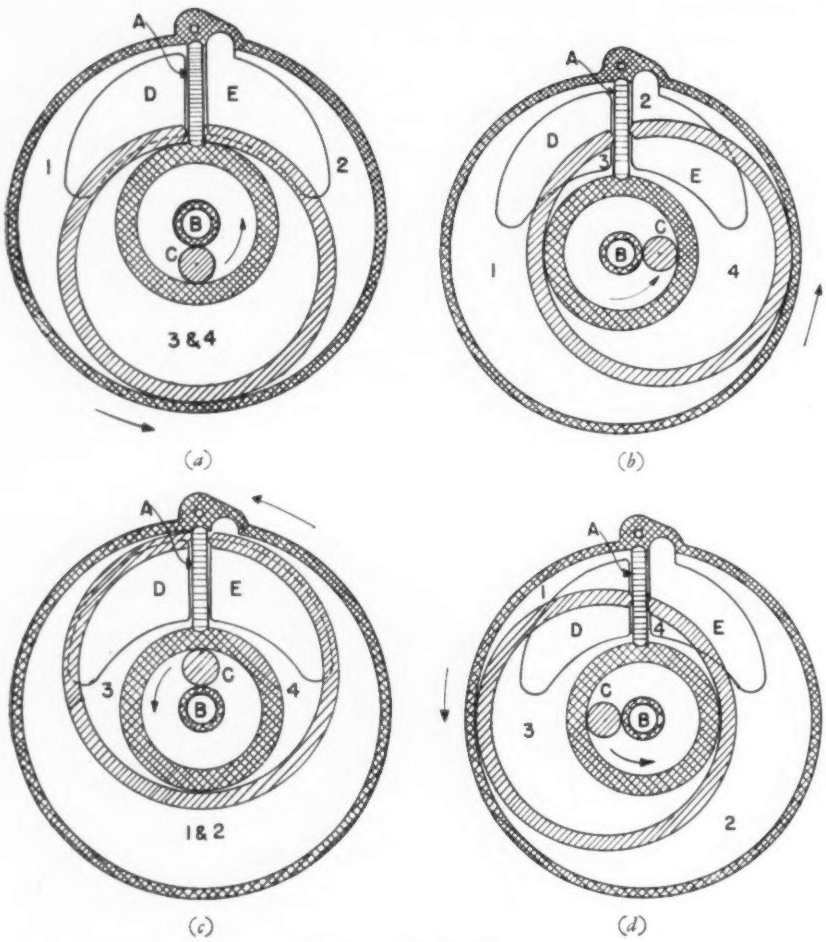


FIG. 6 CROSS SECTIONS THROUGH A PLANETARY-PISTON METER SHOWING SUCCESSIVE POSITIONS OF THE PISTON THROUGHOUT A CYCLE

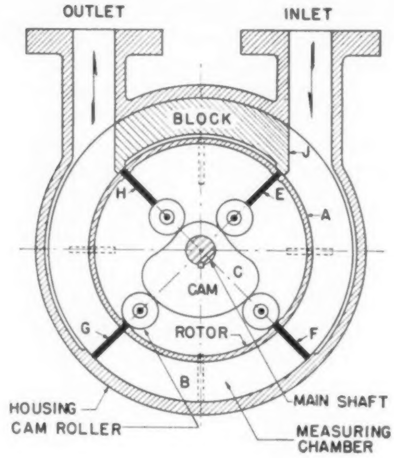


FIG. 7 SECTION THROUGH A SLIDING-VANE METER

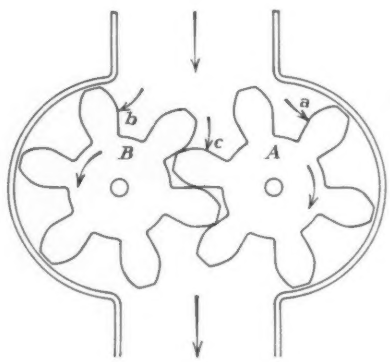


FIG. 8 GEAR TYPE OF METER

respectively, and are located in the cylinder head containing post B, and opposite the closed end of the piston. In Fig. 6 (*a*) fluid is entering chamber 1 from D while fluid in chamber 2 is leaving through E. The fluid in chambers 3 and 4 is sealed off from both the inlet and outlet ports. Succeeding stages in a cycle of the meter operation are shown by Figs. 6 (*b*), (*c*), and (*d*).

The sealing of the measuring chambers depends on sliding contact between the ends of the piston and cylinder and on a combination of rolling and sliding line contact between the cylinder and piston side walls. After being assembled there is no way to change the amount of fluid metered per cycle. This means that if there is to be any adjustment for incorrect registration it may be necessary to change the index gearing or to use a by-pass.

Sliding- or Rotating-Vane Meters. A design of a sliding-vane type of meter is illustrated in Fig. 7. A rotor A is fitted with four sliding vanes E, F, G, and H, which are moved radially inward and outward by the action of the cam rollers on the stationary cam C. The fluid entering the meter exerts a force on vane F which is nearly counterbalanced by the force exerted on vane G by the fluid leaving the meter. The difference between these forces, when there is a flow through the meter, will cause the rotor to rotate. With each quarter turn of the rotor there will be measured out the volume of fluid required to fill the measuring chamber B. Direct passage of fluid from the inlet to outlet is prevented by the block J.

In a rotating-vane meter the sliding vanes of the sliding-vane type are replaced by semicylindrical vanes mounted on longitudinal axes in the periphery of the rotor, and the cam and cam rollers are replaced by gears.

While it would be possible to use sliding contact between the vanes, case, and rotor for sealing the measuring chamber, this would greatly increase the frictional resistance and result in a large pressure loss through the meter. It is therefore more practical to provide very small clearances between these three parts and to depend upon capillary sealing for the tightness of the measuring chamber. If, in addition, low-friction-type bearings are used, the over-all pressure loss of these meters can be kept relatively low. Adjustment of the meter registration can be accomplished by the methods previously mentioned.

Gear or Lobed-Impeller Meters. Fig. 8 illustrates the general features of gear or lobed-impeller meters, which are essentially pumps of this type in reverse action. The measuring chambers are the spaces between the gear teeth and the outside case. To explain the operation of these meters, let f indicate the difference between the inlet and outlet pressures. This differential pressure acts against the tooth surfaces a, b, and c. Due to the meshing of the gear teeth the area acted upon at c is approximately half the sum of the areas at a and b. Therefore, the total torque produced by the pressure acting on a and b will overbalance that produced by the pressure on c, thereby causing the gears to rotate in the directions shown by the arrows.

The number of teeth on each rotor may be reduced until there remain only two teeth or lobes on each rotor. When this is done it is necessary that the rotor shafts be extended through

one or both end walls of the case, and equal tooth spur gears be mounted on them so as to maintain the rotors in the necessary relation to each other.

By careful machining very small clearances may be maintained between the rotors and case and between the two rotors, and thus have effective capillary sealing of the measuring chambers. Also, by the use of suitable bearings the over-all pressure loss can be made very low.

Regardless of the number of teeth used on a rotor, the cross-sectional area of the measuring chamber will be more or less irregular and while it may be possible to calculate this area, and hence the displacement per cycle, it probably will be more satisfactory to determine the relation between meter displacement and the index indication by a calibration test. Indeed, the index on some meters of this type is a simple revolution counter, and the quantity of fluid metered is determined by multiplying the number of revolutions by the displacement per revolution; a procedure which obviates any provision for adjustment.

VELOCITY METERS

In this research we are concerned with only those types of velocity meters which are commercially made for use in closed channels, namely, helical meters and turbine meters. The most important feature differentiating these meters from the types previously described is that the fluid passes through the primary section of the meter in a continuous stream. The action of this fluid stream against the rotative element in the primary section operates the meter index, and since the intensity of this action will depend upon the velocity and density of the fluid, it will vary from time to time. Therefore, it is not practical to make any provision for adjusting the meter but, when necessary, to depend upon a calibration of the meter.

Helical Meter. The helical meter derives its name from the helical vanes on its rotor, as shown in Fig. 9. So far as meter type designation is concerned, the axis of the rotor could be collinear with that of the pipe line, instead of at right angles as here shown. Also it is not essential that the rotor fit closely within the casing, although when it does the meter will be more nearly accurate at all rates of flow, and particularly at

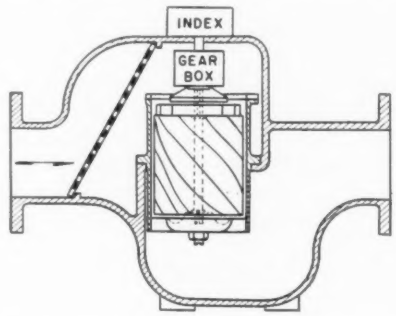


FIG. 9 HELICAL TYPE OF VELOCITY METER

low rates, because it will be more responsive to the action of small flows.

Turbine Meters. The principles of design and operation of turbine meters are similar to those of reaction water turbines of the radial or mixed-flow type. Fig. 10 shows a cutaway view of a turbine meter of the radial outward-flow type, with the path of the fluid through the rotor and guide vanes indicated by arrows. The rotation of the rotor is produced by the reaction of the fluid upon the rotor vanes.

ACKNOWLEDGMENT

The authors wish to express their appreciation of the assistance extended to them by several meter manufacturers who provided some of the illustrations.

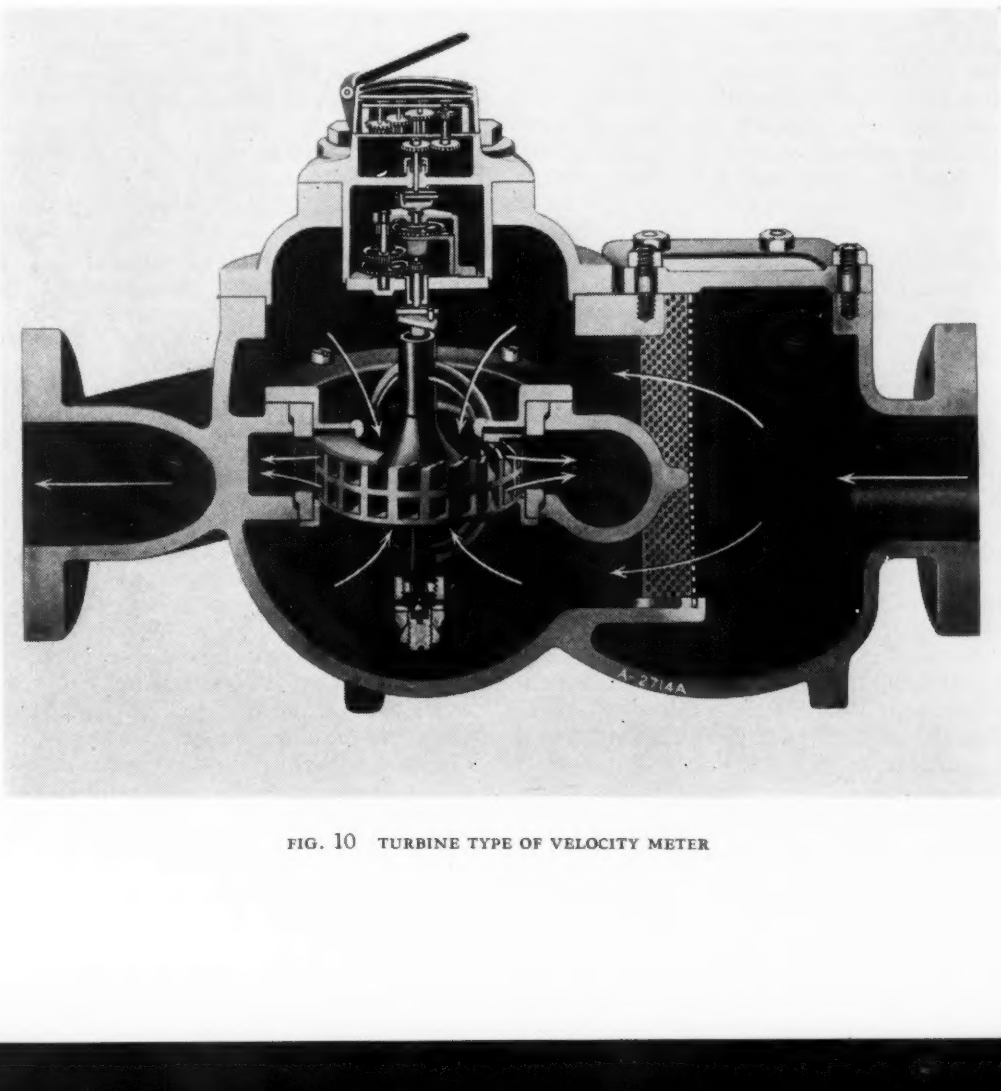


FIG. 10 TURBINE TYPE OF VELOCITY METER

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

50,000 Airplanes for America

VARIOUS SOURCES

WHEN President Roosevelt asked Congress for an air force of 50,000 airplanes, he initiated a controversy among engineers and others about the relative merits of such an air armada and the ways and means to manufacture such a great number of airplanes with the limited facilities available.

Hanson W. Baldwin, military newspaperman, writing in the August, 1940, issue of *Harpers*, states that we do not need and should not attempt to maintain an air force of 50,000 airplanes. Indeed, he continues, the actual requests of the Army and Navy seem to be somewhat more realistic, and it is likely that the goal of 50,000 planes mentioned by the President must have been intended to convey his conviction that the American air forces should be greatly strengthened, rather than to set any such figure. The Navy has asked for 10,000 planes and 16,000 pilots; the Army's exact requests at writing have not been finally determined, but apparently will be about 11,000 planes. Unless a considerable proportion of these are to be training planes or held in reserve (as now seems likely) these figures appear excessive, for the United States has nothing to fear in the air from Japan, which is a weak air power; and even Germany, the world's greatest air power, probably does not maintain in active operating combat squadrons more than 4500 to 8000 planes, and only a handful of these would have range enough to cross even the southern Atlantic—from French West Africa to the hump of Brazil.

Our immediate problem in the air is threefold: (1) Devising the proper organization upon which our air strength can be built and achieving the maximum possible coordination of effort of army planes with navy planes, and of both with the surface forces; (2) speeding up and increasing the supply of trained pilots; and (3) increasing, not so much the capacity of our aircraft factories, which even today is large, but increasing their actual production rate, that today is no more than 8000 to 12,000 annually, and which ought to be, at least for the duration of this present international crisis, perhaps 24,000 to 36,000 annually.

The engineering viewpoint on this subject is presented in *Aviation* for July, 1940, by T. P. Wright, vice-president of engineering, Curtiss-Wright Corp., and member of the Advisory Commission to the Council of National Defense, in an analysis of the time and cost involved in stepping up production from 6000 to the much discussed 50,000 airplanes a year. In his discussion, Mr. Wright deals only with the airplane and its engine and propeller, and omits reference to instruments, special equipment, and armament.

As the aircraft production rate under present capacity conditions of production is only about one fifth of that specified for the proposed program, it is obvious at the outset that an expansion of about 400 per cent is required. A slightly greater expansion is required for the engine business than for the airplane in order to give a balanced production when considering spares requirements. The problem of pilots, mechanics, and airfields necessary for the program is outside the scope of this discussion although it is well to keep these factors in mind when envisioning the whole problem.

There are four methods of aircraft-industry expansion which have been tried abroad and which may be briefly described as: (*a*) Expansion of existing plant facilities; (*b*) the so-called license scheme; (*c*) government operation; and (*d*) the so-called "shadow factory" plan with parent-company control.

It is probable that the first method would prove the most efficient method, from the standpoint of time and money, to meet the current needs. However, the military strategic factors, such as decentralization and location of plants in less vulnerable places, must be recognized. During the last war the license scheme did not prove successful because the product turned out by the licensees was consistently inferior to that of the parent company. Government ownership and operation of factories producing aircraft have not proved successful in any case. The most convincing instance of this fact is, of course, the nationalization of the French aircraft industry by virtue of which the French Air Force, which was the strongest in the world in 1935 and during the years before that time, became by 1938 one of the weakest. The "shadow factory" plan has several variations but is essentially one which presumes control by the parent company that developed the design, with manufacture centered in shadow assembly plants. Engineering changes and new developments, as well as maintenance of quality standards through inspection, are also controlled entirely by the parent company. This is the scheme by means of which it is felt the expansion program can best be carried out from the standpoint of time and cost. In England, in those cases where this plan has been carried through with full parent-company control, it has been eminently successful. Where it approximated a license arrangement it failed. In all cases, the expansion of the industry through shadow factories should be financed entirely by the government, which in turn would lease them to the parent companies who are to operate them during the period of such operation.

Cost of the additional plant necessary to produce 50,000 airplanes a year, including land, factory buildings, offices, power and lighting facilities, heating plants, machine tools, test houses, and auxiliary equipment, would be $572,000,000. As explained before, it appears necessary that this expansion be carried through with government funds, the facilities being subsequently leased to those concerns who are to be responsible for producing the airplanes, engines, and propellers in such added space.

The next step in the analysis by Mr. Wright is the production meaning of a 50,000-planes-a-year aircraft industry. His total values, as worked out, indicate (*a*) the need of producing 500,500,000 lb of aircraft a year, (*b*) plant requirements totaling 75,600,000 sq ft of floor space (including factories and offices), (*c*) a manufacturing personnel, both direct and indirect, of 680,000 persons, and (*d*) an anticipated annual cost of producing 50,000 airplanes a year of approximately $3,560,000,000.

It should be noted that the present American air force is about

the dimensions of that which Germany possessed in 1936. Germany's present air force (as of May 1, 1940) has been estimated at about 31,000 planes. Thus, it took them about four years to go from 4300 to 31,000 total air strength. It is fairly certain that the United States, if it puts its mind to it, could duplicate this feat if not surpass it.

It is estimated that an airplane production rate of approximately 2000 a month, or 24,000 a year, can be achieved in $2^1/_2$ years or by January, 1943; a rate of production of 3000 airplanes a month, or 36,000 a year can be attained in four years, or by the spring of 1944; and a rate of just over 4000 airplanes a month, or 50,000 planes a year can be realized in five years, or by July, 1945.

If these rates of production materialize, it will mean that we will reach our first objectives of an air force of 25,000 planes (and assuming continued deliveries to the Allies on current contracts, plus substantial anticipated ones—assumed to total 50 per cent of our production—and allowing for 20 per cent depletion in the American air force due to operating losses and obsolescence) in about $2^1/_2$ years, or by January, 1943. The rate of production at that time will be about 25,000 planes a year so that we should obtain an air force of 50,000 airplanes (if that is then desired) in an additional time of a little over one year, or by the spring of 1944. Shortly thereafter our annual production rate on a capacity basis will approach 50,000 planes a year so that we will be able to maintain an air force then desired on a substantially less than capacity basis.

Bofors 40-Mm Antiaircraft Gun

MACHINERY (GREAT BRITAIN)

ONE of the most effective weapons being used by the British against German dive bombers and low-flying, machine-gunning airplanes is the Bofors antiaircraft gun, designed in Sweden and manufactured by the hundreds at government ordnance factories and privately owned plants in Great Britain. The brief description which follows is taken from an article in *Machinery* (Great Britain), June 27, 1940, which discusses the gun's manufacture and operation.

The Bofors gun fires shells of 40-mm diameter in rapid bursts, and at speeds of approximately 120 rounds per minute. It is regarded as a highly efficient antiaircraft weapon for duties intermediate between those of the high-altitude (40,000 ft) guns of the 3.7-in. class and the machine guns of the Vickers, Bren, or Lewis type, which are capable of firing rifle bullets at rates up to 600 rounds per minute.

The design of the 40-mm gun, shown in Fig. 1, provides for rapid movement from place to place when towed by a high-speed tractor. In action the gun is controlled by two members of the crew, one sitting on either side of it. With the help of double cranks, the elevating mechanism is operated from one side, and the turning motion from the other. The four pneumatic-tired wheels are spring-loaded, and the gun can be brought rapidly into action by lowering it, together with its platform, to the ground. Four screw-operated jacks, which may be seen in the illustration, provide support for the platform, and spirit levels are fitted to insure correct setting in the horizontal plane. For anchoring the equipment, four pickets, each about two feet in length, are driven into the ground with a maul. A withdrawing bar is used for their rapid removal.

Interposed between the gun mounting and the platform is a turntable fitted with ball bearings. A gear ring of large diameter is used for turning the gun to give the required direction of fire, and is connected by gearing to the double-crank handles at the right-hand side. Bolted to the underside of the breech casing is the elevating arc, which is, in turn, geared to the elevating cranks at the left-hand side of the gun for controlling the angle of fire.

The gun assembly proper comprises the barrel, the breech casing, and the breech ring and mechanism. The barrel is machined from a heat-treated forging of chrome-nickel steel, and the rear end has external interrupted threads to enable it to be assembled rapidly in the breech ring. Near the middle of the gun barrel is a collar which is screwed into position and holds the recuperator spring in compression. The forward end of the barrel is screwed to receive a funnel-shaped flame-guard which is screwed against a copper ring and retained by three setscrews. There are 16 rifling grooves, with a twist increasing from one turn in a length equal to 45 diameters at the breech end to one in 30 at the muzzle. The breech casing forms a chamber for the breech ring, breech block, and loading mechanism, and is of a general rectangular shape at the rear, while the front is cylindrical and slotted. Near the rear end of the casing are flanged trunnions which fit into trunnion bearings carried by the gun mounting.

It is possible to set the gun for single-shot firing or for continuous fire by moving a small lever. With the lever in the continuous position, firing is automatic until the rounds in the magazine are exhausted. With continued loading, there-

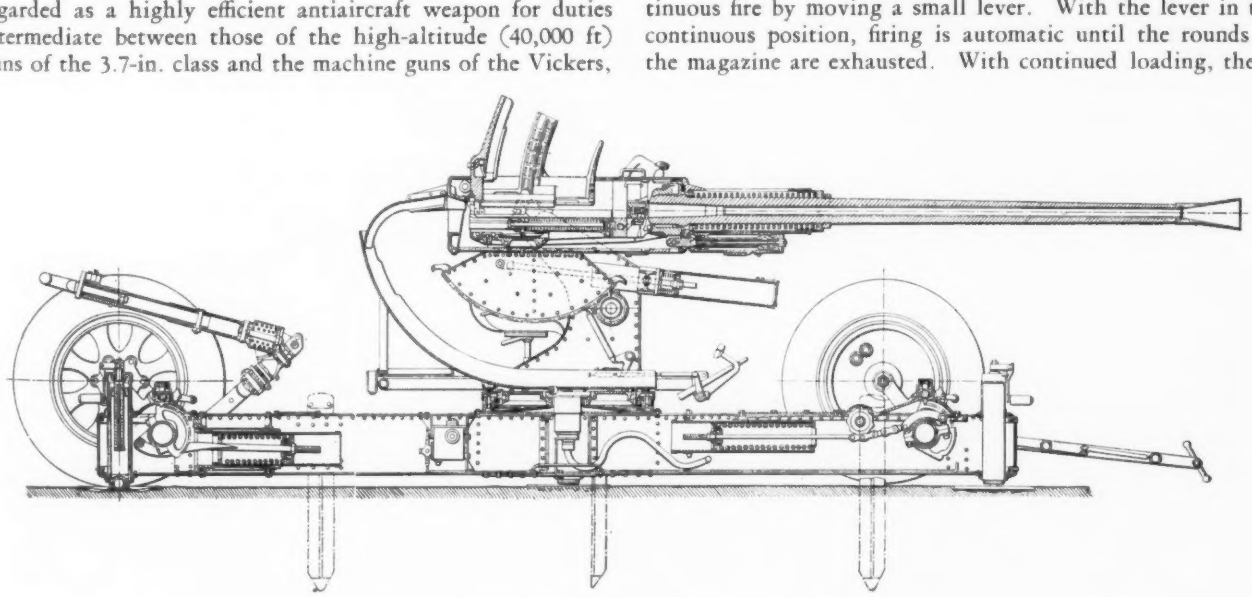


FIG. 1 DIAGRAM OF THE BOFORS ANTIAIRCRAFT GUN

fore, the burst of fire can be maintained indefinitely, the limiting factor being the heat generated in the barrel. The shock of discharge is absorbed by the recoil system, which not only brings the gun to rest after the recoil and restores it to its firing position, but also provides for the opening of the breech, the ejection of the spent-cartridge case, and reloading. Spent-cartridge cases are ejected from the breech at considerable velocity, and are directed toward the front of the gun by a system of troughing.

Direct-Fired Unit Heaters

METROPOLITAN SECTION, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THIRTY direct-fired, hot-air unit heaters developing 3,150,000 Btu per hr were chosen to heat the hangars at La Guardia Field, New York City's new airport. An article describing the airport was published in MECHANICAL ENGINEERING, February, 1940. Six heaters are located in the seaplane hangar, and four in each of the six landplane hangars. According to a paper presented by R. M. Rush and H. A. Pietsch, Dravo Corp., at a meeting of the Metropolitan Section, The American Society of Mechanical Engineers, on March 29, 1940, the world's largest airport has 33,000,000 cu ft of air space in its seven hangars, and doors 160 ft long and 40 ft high are used in each hangar. The design and construction of the unit heaters are described in the following abstract taken from the paper.

As shown in Fig. 2, the upper half of the combustion chamber is "black surface" receiving heat principally by radiation from brickwork, flame, and gases. The lower half is lined with 9 in. of lightweight, insulating firebrick, laid so that there is very little space between its outer surface and the corrugated metal walls of the combustion chamber. Transmission of heat by radiation occurs because the brickwork becomes radiant and shines into the heat-absorbing surface of the upper half of the combustion chamber. The glowing trough of brickwork is ideal likewise for the completion of combustion.

The combustion chamber in this heater is a gastight, welded steel chamber with round top and bottom. It is constructed throughout of steel plate, with corrugations $1^1/_2$ in. deep. The effect of the corrugation is to increase the surface of the metal about 50 per cent over that of a plain area. In addition these

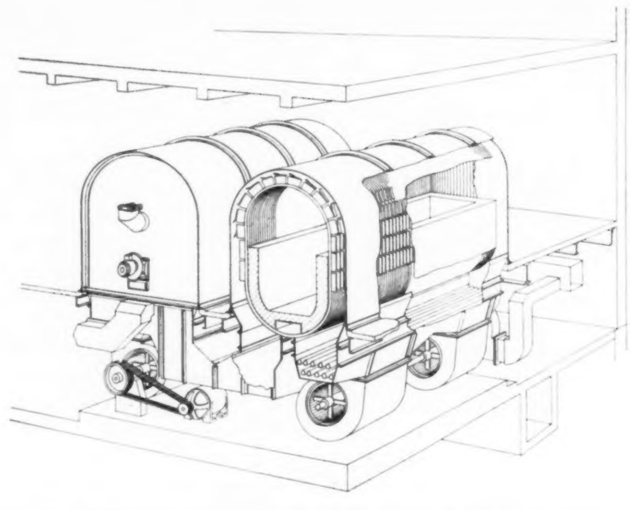


FIG. 2 BANK OF LEE DIRECT-FIRED UNIT HEATERS INSTALLED AT LA GUARDIA FIELD

corrugations take up expansion and contraction strains due to temperature changes. The upper portion of the combustion chamber is covered with specially shaped deflectors and fins which direct the air stream down into the valleys of the corrugations with great turbulence. Each heater has about 500 sq ft of fin surface securely welded to the top or hill of the corrugations.

The rotary-type oil burners used in these heaters operate on No. 6 heavy fuel oil. Each burner is equipped with gas-electric ignition. Oil is circulated under constant pressure in a loop system from underground tanks, equipped with heating coils.

The outer casing which forms the outside of the air passage is made of panels which can be unbolted and moved lengthwise for inspecting the outer surface of the combustion chamber. It is noted by the authors that in this heater, the air being heated is always under positive pressure, while the gases in the combustion chamber are always under a slight negative pressure, which means that the products of combustion can never, under any circumstances, leak into the air stream. Each of the thirty heaters at La Guardia Field is equipped with a set of fans consisting of two double-inlet, forward-curve-blade blowers, designed for a combined output of 36,900 cfm at 3 in. pressure,

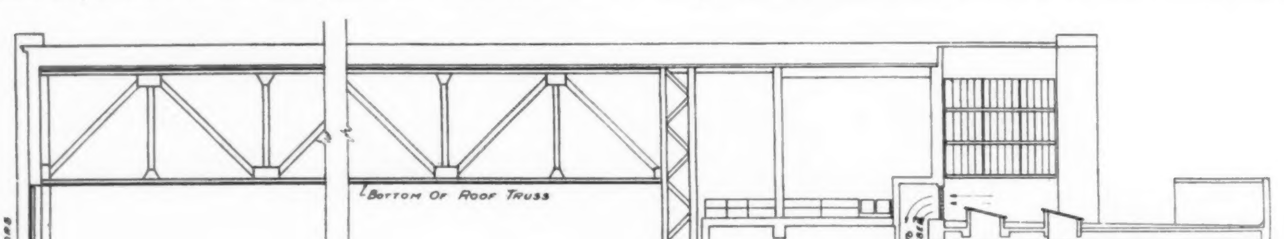


FIG. 3 DIAGRAM OF HEATING SYSTEM UTILIZED IN HANGARS AT LA GUARDIA FIELD

when operating at 800 rpm. This pressure was necessary not only to overcome the resistance through the heater, but also through the duct work and the distributing tunnels. Both fan rotors are mounted on a large hollow shaft running between two ball bearings. This design permits the fans to run always below their critical speed even though the bearings are widely separated, located as they are about 12 ft apart in pedestals at the outer side of each blower. On one end of the fan shaft is a straight-blade exhaust fan designed to run at 800 rpm for 2000 cfm at $2^1/_2$ in. static pressure and 400 F. At the exhaust-fan inlet is an adjustable damper to maintain the proper negative pressure in the combustion chamber. On the other end of the fan shaft is a V-belt pulley for driving from the 30-hp electric motor. On the motor-shaft extension is a variable-pitch pulley.

The arrangement of the equipment is shown in Fig. 3 which is a diagrammatic drawing of the six heaters in the seaplane hangar. Heated air from the heaters is carried underground in tunnels to grilles about one foot wide in the hangar floor at the large folding doors. When the doors are open the hot air forms a curtain to prevent cold air from rushing into the building. Meanwhile, cold air from the hangar floor enters the plenum chamber through louvers and is fed to the fans. This method of handling the cold air prevents the hot air from rising immediately to the roof. As a result the difference in temperature between roof and floor is only a few degrees. The flue across the bottom of the heater is connected at the burner end to an economizer located between the fan outlets and the heater cold-air inlet. The fans, motors, duct work, economizers, smoke breeching, and exhaust fans are all located below the heater room proper, in a plenum chamber on the hangar floor level. As all of the equipment in this compartment is surrounded by rapidly moving air on its way to the fans, any radiated heat is picked up by the cold air and, therefore, not lost. The heater room is tightly sealed from the plenum chamber so that the only air circulating around the heaters, in that room, is the air for combustion.

The acceptance test was conducted on Dec. 4, 1939, by engineers of the City of New York, the manufacturer, and the contractor. According to the authors, the test was made, as far as possible, in accordance with the heat-balance method outlined in the Power Test Code of the A.S.M.E. Briefly, results were as follows: Btu per hr output, 3,260,000; efficiency, 86.68 per cent; CO_2 in exhaust gases, 13.42 per cent; temperature of exhaust gases, 389 F; and air heated per unit, 36,900 cfm.

Power Plant of New *S.S. America*

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

STARTED in August, 1938, launched in August, 1939, and completing its first trip at about the time this magazine reaches the reader, the *S.S. America* is truly a great tribute to the many people whose ideas and efforts made this achievement possible. The $17,000,000 vessel incorporates several new features made necessary by recent safety laws and regulations. Following an inspection by members of the Society of Naval Architects and Marine Engineers attending the spring meeting of the organization in Newport News, Va., May 17, 1940, this largest, fastest, and costliest passenger vessel ever built in the United States was described at a session in a 34-page paper presented by Harold F. Norton, naval architect, and John F. Nichols, chief engineer, the Newport News Shipbuilding and Dry Dock Co. Details of the new ship are discussed and illustrated with photographs and drawings.

For the benefit of the readers of MECHANICAL ENGINEERING, excerpts from the paper dealing with the mechanical and power-plant features of the *America* are given here. According to the authors, the most unusual feature of the 22-knot 24,000-ton ship is the separated boiler rooms, with engine room between, the uptakes going up through the machinery hatch. All three main machinery spaces are protected from collision damage by deep fuel-oil tanks on each side. The advantage of this arrangement is greater space for passengers and stores, while the disadvantages are a greater dependence in the machinery spaces upon forced ventilation and less ready accessibility for making repairs to machinery.

The design of the machinery, as well as of the hull, represents a compromise between the ideas of at least four elements, the United States Maritime Commission, the owners, the U. S. Navy, and the builders. The machinery layout was naturally strongly affected by the fact that the vessel was primarily to be a running mate for the *Manhattan* and *Washington*, which had already been in service for several years, had given excellent satisfaction to the owners, and had established a splendid reputation with the traveling public. The power was increased just enough to give a little more margin of speed for making up lost time when required. Presumably, the vessel would often be operated by crews, recruited from the other two vessels, and, therefore, machinery arranged in a somewhat similar manner to theirs would be advantageous.

A careful preliminary study was made of the service record of the *Manhattan* and *Washington* with a view to retaining what was good and making such improvements as seemed practicable. For this reason many of the general features were retained, twin screws, triple turbines with reduction gears, six boilers. The steam pressure and temperature have been advanced somewhat from the previous practice and the high-pressure turbine was of the impulse type throughout, increased in speed and fitted with double-reduction gearing. The intermediate and low-pressure turbines are of moderate speed and single reduction is retained, the main gear being the largest marine gear so far produced in this country. The boilers were made of the encased type which permits the obvious advantage of open fire rooms. Due to the increased beam it was found practicable to arrange all the propulsion auxiliaries in the engine and boiler rooms, thus reducing the length of the machinery space and of the main steam pipes. The main condensers were located beneath the low-pressure turbines instead of above, thereby insuring reliable drainage from the turbines at all times. Condenser circulation by scoops was retained. This arrangement, which is an offshoot from naval practice, has been found most satisfactory in service; is probably of equal efficiency with pumps; and has the advantage of saving space and of eliminating the necessity of maintaining two vital constant running auxiliaries. The contaminated steam system was retained, but reduced in capacity and complexity. The main feed and condensate system is of the completely closed deaerating type.

There will be found a noticeable absence of nonvital automatic equipment in marked contrast to the present-day tendency, the operators preferring to rely on the results obtainable with a trained and dependable personnel. The arrangement of machinery is as shown in Fig. 4.

The propulsion turbines were designed and built by the Newport News Shipbuilding and Dry Dock Company. Each set of turbines consists of one high-pressure, one intermediate-pressure, and one low-pressure turbine in series. The turbines are designed to deliver to the propellers a total of 34,000 shp at 128 rpm of the propellers when supplied with steam at 400 psi gage and 715 F at the chests and exhausting at 29 in. vacuum, and are designed for approximately equal distribution of power. The astern elements are designed to deliver a total of 19,500

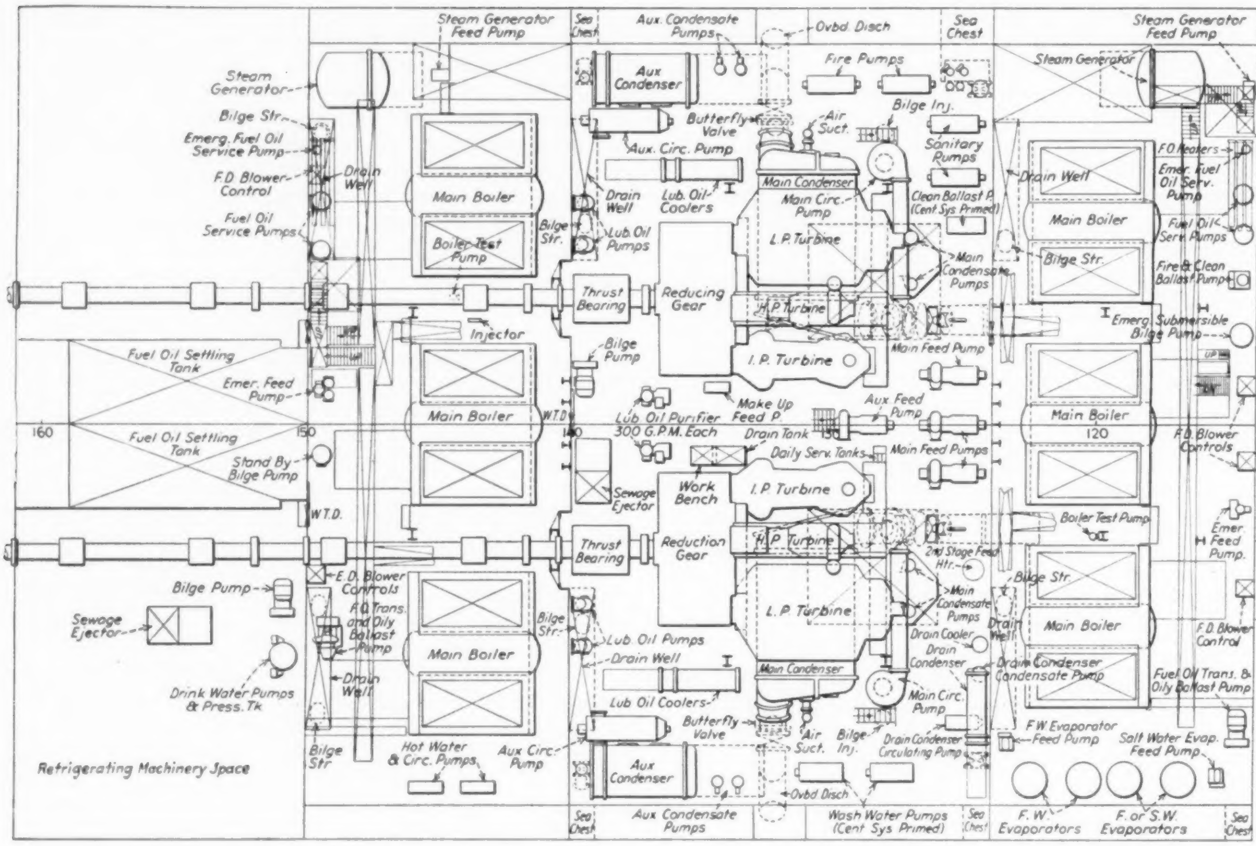


FIG. 4 ARRANGEMENT OF MACHINERY IN NEW S.S. "AMERICA"

shp at 95 rpm with steam at 385 psi and 715 F at the chest. Turbines are capable of operating continuously at 10 per cent overload. Three hand-operated control valves on the high-pressure chest provide economical operation from overload to approximately 15 knots cruising speed.

There are two sets of De Laval reduction gears of the double helical type. The intermediate-pressure and low-pressure turbines drive through single reduction, and the high-pressure turbine through double-reduction gearing. The principal particulars of the gears are as follows:

	Pitch diameter, in.	Face, in.	Helix angle, deg
High-speed pinions...	13.00	....	....
High-speed gear......	28.40	Two 15.0	45
Low-speed pinions....	14.80	....	....
Low-speed gear.......	174.00	Two 25.5	30

All turbine rotors are connected to the pinions by claw-type flexible couplings. The high-pressure high-speed gear is connected to the high-pressure low-speed pinion through a quill shaft and claw-type coupling. The pinions are of nickel-steel forgings, 200 to 240 Brinell. The gear rims, and the high-speed gear which is solid, are of carbon steel 160 to 190 Brinell. The spider of the low-speed gear is of special cast iron in two halves bolted together. The high-speed gear housing is of semisteel; the low-speed gear housing is of welded construction with steel castings and plates.

Steam is generated by six Babcock & Wilcox water-tube, three-drum express-type, oil-burning boilers. The boilers are totally encased so as to operate under forced draft in open fire rooms and are fitted with superheaters, desuperheaters, and air heaters. The air casings are double, the outer surface being kept cool by having the outer space receive a portion of the air direct from the blowers.

The boilers have a total evaporating surface of 63,000 square feet and are designed for a total evaporation of 315,000 pounds per hour normal and 346,000 pounds per hour maximum with 300 F feed temperature. The normal steam conditions at the superheater outlet are 425 psi gage and 725 F. The boilers are designed for a maximum steam pressure of 500 psi gage.

Superheated steam is supplied to the main turbines, auxiliary generators, main and auxiliary feed pumps, main circulating pumps, main and auxiliary air ejectors, and to the high-pressure evaporator. Desuperheated steam is supplied to the fresh-water evaporators, fresh and salt-water evaporators, ship's heating system, fresh-water heaters, laundry, galley, and to the drain condenser air ejectors. Saturated steam direct from the boiler drums is supplied to the whistles and to the reciprocating steam pumps.

Ventilation air is supplied by 50 supply systems and removed by 32 exhaust systems. Air is supplied to all passenger staterooms at an average rate of about 40 cfm per person. A change of air is supplied every eight minutes to the public spaces, every six minutes to the crew's living spaces, and every 4.5 minutes to the air-conditioned dining saloons. Exhaust ventilation is provided for all public spaces, toilets and showers, galley, pantries, hospitals, and all other spaces necessary for the removal of heat and odors. All cargo spaces except the refrigerated cargo spaces have mechanical supply at the rate of one change every 30 minutes, and natural exhaust.

Each boiler room is ventilated by two 50,000-cfm supply fans and the engine rooms by two 50,000-cfm supply fans and by two 25,000-cfm exhaust fans which draw from the generator flats, switchboard, and operating platform.

In appearance the *America* is distinctive with its slightly curved

raking stem, the high freeboard forward, and the streamlined treatment of the bridge front and superstructure, together with the unusual design of the wide-spaced stacks with their Sampan tops, to deflect smoke away from the sports deck.

Panel Warming and Cooling

HEATING, PIPING, AND AIR CONDITIONING

SINCE the appearance in April, 1938, in this section, of an article describing the use of panel warming in Europe, this method of heating has been utilized in American office buildings, cathedrals, hospitals, and homes. One of the most recent installations was made in the Everett, Wash., combination high-school, civic-auditorium, and gymnasium building. The installation is described by E. L. Weber in an article appearing in the May, 1940, issue of *Heating, Piping, and Air Conditioning*. The panel-warming system is not only used for heating purposes but also for cooling.

There are steel pipe coils in the ceiling of the one-story section, through which water at a maximum temperature of 130 F is circulated. A 4000-gal capacity hot-water storage tank was installed in the central boiler plant to supply heat for the gymnasium showers and for the panel heating system. The water for the latter service is heated in a countercurrent flow converter with a capacity of 1,000,000 Btu per hr when heating water from 115 F to 130 F, and supplied with water from the storage tank at 140 F. The converter is also provided with a cold-water connection for cooling the panel system by means of city water during the summer. Neither the water from the hot-water storage tank, nor cold city water, is circulated through the panel system as the continuous introduction of new water introduces air into the system and may cause scaling or pitting of the pipe.

The panel coils contain nearly 11,000 lineal feet of $^1/_2$- and $^3/_4$-in. steel pipe bent on 6-in. centers. All joints were welded and tested to 500-psi air pressure under water and a steel ball was blown through each coil to assure the absence of "inside welds" or other obstructions. These coils are embedded in the concrete ceiling slabs in the gymnasium auxiliary rooms. The offices and music rooms all have furred ceilings and the coils are wired to $1^1/_4$-in. pipe battens hung from the roof slabs. The first coat of plaster was carefully "pushed through" the metal lath to give an intimate contact with the coils. A second coat of plaster was next applied and in the third coat of plaster, a scrim was embedded while the plaster was being "floated on."

The flow and return mains are run in the space above the coils. A supply branch to each room drops down in the inside partition, is provided with a shut-off and drain valve, and then rises to supply the panel coils.

Two-Engine Truck

SOCIETY OF AUTOMOTIVE ENGINEERS

WHAT can be done at the present state of motor-vehicle design to get improved performance? This question is answered with various illustrations by Austin M. Wolf in a paper which was presented at the summer meeting of the Society of Automotive Engineers, June 9–14, 1940. After discussing weight, gear ratios, fuel mixtures, compression ratios, and larger engines, Mr. Wolf describes a two-engine truck.

The contention is that for particular classes of work over certain regions, a single large engine must be operated a good part of the time at a very unfavorable part-throttle opening, resulting in poor fuel economy. A two-engine unit in its field can bring about a better engine load factor on the individual engine or the dual engines, than in the case of one large engine favorable by many gear ratios.

A two-engine truck is shown in Fig. 5. The installation consists of a four-cylinder Hercules engine (developing 47 hp at 3100 rpm and 93 lb-ft torque at 2000 rpm) delivering its output to the transmission of a Chevrolet truck. It is effective in second, third, and high only, so as not to overload the driving line in low gear. The booster engine cuts in and out automatically when additional power is required, being controlled by a vehicle-speed governor, a vacuum governor connected to the Chevrolet engine, an accelerator governor, and the booster unit's automatic throttle. Using this booster engine, 94.1 ton-miles per hr per gal have been obtained as compared with 87.0 without the booster. In this case, the gross vehicle weight was 31,000 lb of which 18,640 lb was pay load. The installation of the extra engine, together with two 30-gal auxiliary gasoline tanks hung on the side of the chassis, air brakes, subframe, and fifth wheel, increased the chassis weight from 3970 lb to 5630 lb.

It is Mr. Wolf's opinion that a field exists for two-engine designs.

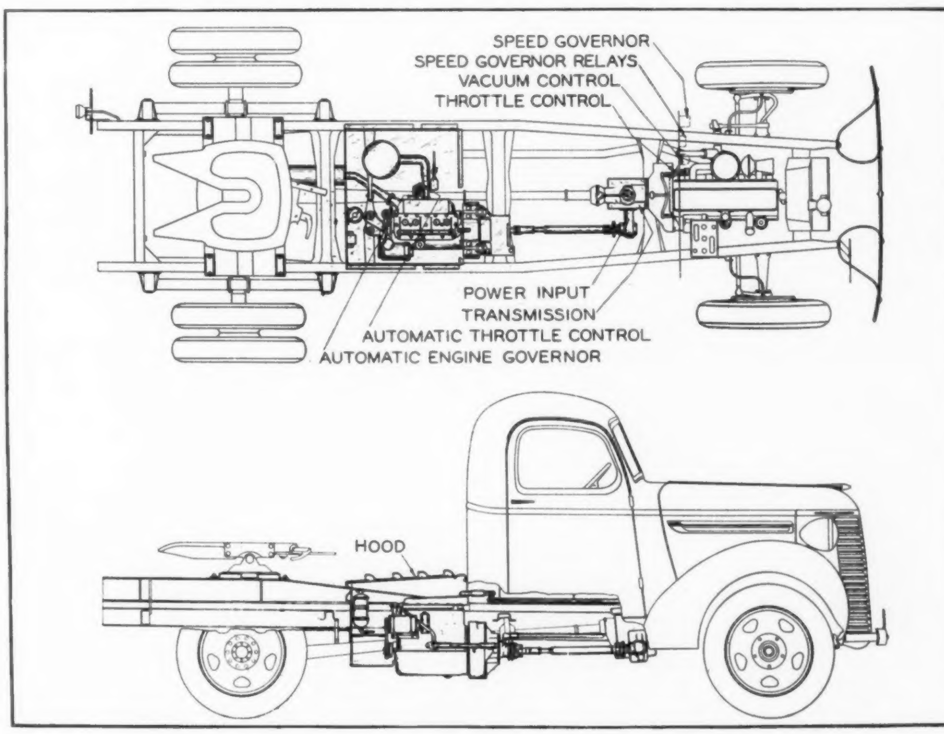


FIG. 5 CHEVROLET TRUCK EQUIPPED WITH CLARK BOOSTER UNIT UTILIZING HERCULES ENGINE

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Review of Progress in Feedwater Treatment[1]

COMMENT BY O. F. CAMPBELL[2]

This paper is somewhat unique in that it presents in understandable terms what must be accomplished for satisfactory boiler-feedwater treatment. Executives of corporations both large and small can obtain from it a general understanding of boiler-feedwater treatment and can readily understand that adequate treatment of boiler feedwater for the higher pressures and temperatures can be accomplished. These executives can then determine the economies of operating their boiler plants at the elevated temperatures and pressures with safety.

The paper brings out rather forcefully the necessity of experienced chemists for the control of boiler-feedwater treatment, thereby preventing scale, corrosion, carry-over, and caustic embrittlement, even in the face of 90 per cent or better raw make-up water. Research chemists are daily pointing out that previous understanding of boiler-water treatment has been incomplete and that further research will have changed many facts previously accepted. The final result will be the satisfactory treatment of boiler feedwater for any temperature and pressure, for any percentage of raw make-up water for any combination of salts that might be found in the raw water. The outlook is indeed encouraging for all concerned with water treatment.

COMMENT BY M. K. DREWRY[3]

"Until a few years ago, the difficulty confronting students of corrosion was not to find an explanation of the attack, but rather to account for the fact that metals survived at all." Thus, the all-important role of natural protective coatings on ferrous materials is aptly emphasized by Evans.[4] That iron would not qualify as an engineering material if not preserved by minute coatings is probably not generally or adequately appreciated.

Speller emphasizes the controlling nature of protective coatings, stressing that the "tendency" toward corrosion is not the criterion of corrosion rates, but that the "resistance" of barriers to corrosion is predominantly important. His text[5] proved of no little assistance in coping with a case of extremely rapid corrosion in a high-pressure boiler.

Growing significance of natural protective coatings and lessening consideration of circulation are anticipated in those cases of corrosion where metal temperatures are within 100 to 200 deg of water temperatures.

The obvious trend toward lower boiler-water alkalinities apparently warrants specific mention. Vital value in favorably improving or definitely preventing corrosion, carry-over, and embrittlement troubles can often be credited to low alkalinity. Most 1300-psi boilers are operating with less than 50 ppm phenolphthalein alkalinity, and some have operated best for several years without any caustic-soda alkalinity.

[1] "Review of Progress in Feedwater Treatment," by C. H. Fellows, MECHANICAL ENGINEERING, May, 1940, pp. 392–396.

[2] Combustion Engineer, Sinclair Refining Co., East Chicago, Ind. Mem. A.S.M.E.

[3] Assistant Chief Engineer of Power Plants, Wisconsin Electric Power Company, Milwaukee, Wis. Mem. A.S.M.E.

[4] "Metallic Corrosion Passivity and Protection," by U. R. Evans, Longmans, Green & Company, New York, N. Y., 1937.

[5] "Corrosion—Causes and Prevention," by F. N. Speller, McGraw-Hill Book Company, Inc., New York, N. Y., 1935.

Discovery of Promising Freshman Engineers

TO THE EDITOR:

Among the numerous papers presented at the annual convention of the Society for the Promotion of Engineering Education at the University of California, June 24–28, were three reports of the coordinated committees on personal development: "What Industry Considers Promising Material," "Exploring Promise in the Undergraduate," and "Discovery of Promising Freshman Engineers."

The first report, that of the committee headed by Prof. John R. Bangs, of Cornell, stressed particularly the growing sensitivity of industry to the necessity of character and proper personality in addition to scholastic and academic advancement. The report placed a considerable responsibility on the engineering colleges for the development of character and desirable personal qualities.

The second report, by Dr. Edward K. Strong, Jr., of Stanford University, stressed some of the possibilities of discovering and exploring promising human engineering material. The report indicated that every means known to modern science, particularly along the lines of psychology and statistics, was being used to select and guide young people in the choice of a profession or lifework.

The last report, of the committee headed by R. L. Sackett, showed the participation of engineers in high-school counseling of those boys who wanted to know what engineering is and the higher standards for admission to engineering schools as compared with practice ten years ago.

There is a growing sentiment toward seeking an inventory of boy personality and character rather than scholarship only, in selecting those admitted. It is only in embryo at present.

A larger variety of tests is being used as an aid in selection or in the guidance of those who are not progressing satisfactorily.

The percentage dropped because of poor performance in engineering education is decreasing as a result of better guidance and selection. As a result, the percentage of those admitted who are graduated shows signs of increasing.

R. L. SACKETT.[6]

What They Think Outside College Walls

TO THE EDITOR:

In the June issue appeared an editorial entitled "What They Think at Purdue." Undoubtedly the same thoughts are largely prevalent at every engineering college in the United States.

With every due regard for the establishment of professional ideals and for the furtherance of honor and recognition by fellow engineers as a reward for endeavor, I venture to criticize the value of such polled results as were obtained at Purdue University.

First of all, what could be expected from any such undergraduate body other

[6] Chairman, Committee on Student Selection and Guidance, Engineers' Council for Professional Development, New York, N. Y. Fellow A.S.M.E.

than the answers that came forth? And of what value are these answers except to show to a more enlightened group that another fledgling class has been released to a very material world, where near-cloistered college life abruptly ends, and with that end, inexorably comes some shattering of those ideals and consequent readjustment.

Where in this modern life are recognition and salary divorced? What is a better measure of a man's ability than the salary he receives? What business venture could succeed if the heads of that business emphasized the accrual of good will and neglected the consideration of gaining a profit? And do not we all, engineers though we are, have reason to run our lives much as the corporation heads operate their organizations?

Newly graduated engineers, if all of these pointed questions seem harsh, consult the man who doesn't have his head in the clouds, a man who has had a chance to lose his college-day superciliousness. You'll soon meet him, and many like him, in your business world acquaintances and he'll help you get your feet upon the ground. Keep your ideals—all that you can, but revolt at hypocrisy. Life is now your adversary and never underestimate him.

A college education will never hurt you if you're willing to learn something after you are graduated.

W. EUGENE HARRIS.[7]

[7] Summerville, S. C. Jun. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

Following is a record of the interpretations of this Committee formulated at the meeting of June 28, 1940, which were subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 883 (Reopened)

(Special Ruling)

Inquiry: May the plates of jacketed unfired pressure vessels, welded according to Par. U-69, be stayed by welded stays applied substantially as shown in Fig. 36?

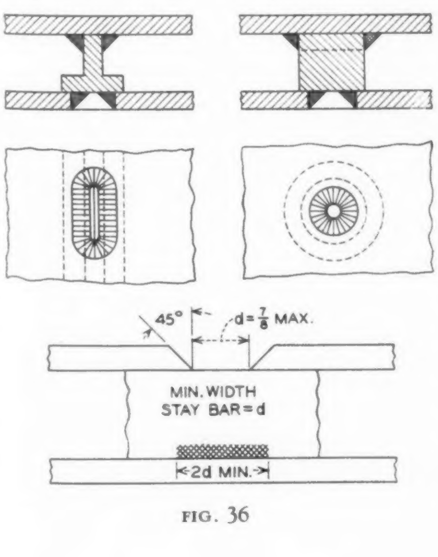


FIG. 36

Reply: It is the opinion of the Committee that the arrangement described may be used in the construction of Code vessels provided: (1) The pressure does not exceed 150 lb per sq in.; (2) the plates do not exceed $^{1}/_{2}$ in. in thickness; (3) the throats of the welds do not exceed the plate thickness; (4) the inside welds are properly inspected before the attachment of the closing plates; (5) the stresses calculated on the throat dimension of the weld do not exceed 5600 lb per sq in.; and (6) the maximum diameter or width of the hole in the plate does not exceed $^{7}/_{8}$ in. The welding operators must be qualified under Par. U-69 and stress relieving of the welds is not required.

CASE No. 908

(Interpretation of Par. P-268o)

Inquiry: Par. P-268*o* requires that all welding of fusion-welded connections be equivalent to that required under the rules in Pars. P-101 to P-111, inclusive. Since the conditions of the tests required by Par. P-112 are more nearly equivalent to the welding conditions encountered in nozzle construction, will it meet the intent of the Code to use welding operators who have qualified under the requirements of that paragraph (Par. P-112) to weld such nozzle connections?

Reply: It is the opinion of the Committee that an operator meeting the requirements of Par. P-112 may also be considered qualified to weld connections as called for by Par. P-268*o*.

CASE No. 909

(Special Ruling)

Inquiry: A.S.M.E. Code Specifications S-24 and S-47 authorize the use of Muntz metal tubes, but there is no specification covering Muntz metal plate. May Muntz metal complying with A.S.T.M. Specification B 57–27 be used for the tube sheets of unfired pressure vessels?

Reply: Pending inclusion in the Code of a specification covering Muntz metal plate, it is the opinion of the Committee that this material may be used with maximum allowable working stresses as given in Table U-4 and for metal operating temperatures not exceeding 300 F.

Revision and Addendum to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place in the code.

The following proposed revision has been approved for publication as a proposed addendum to the code. It is submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-115. Insert the following as a new paragraph:

P-115. Fire-tube boilers may be constructed by inserting an outwardly flanged tube sheet in the shell, attaching it thereto by a circumferential fillet weld provided:

(1) The tube sheet is supported by braces or tubes;
(2) The joint is wholly within the shell and forms no part thereof;
(3) The shell at the weld is not in contact with primary furnace gases;
(4) The throat of the full fillet weld is equal to 0.7 of the thickness of the head;
(5) The construction conforms in all other respects to Code requirements including the type of welding, stress relieving, etc., but radiographing is not required;
(6) This construction shall not be used on the rear head of an H.R.T. boiler.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

My Fifty Years in Engineering

My 50 Years in Engineering. By Embury A. Hitchcock in collaboration with Merrill Weed. The Caxton Printers, Ltd., Caldwell, Idaho, 1939. Cloth, 6 × 9 in., 277 pp., illus., $3.

Reviewed by J. M. Barnes[1]

THIS is a book every practicing engineer will enjoy reading and from which he will profit. Every young man, especially those planning to enter engineering colleges, will also find it of great value.

The cover of the book points out one of the outstanding characteristics of Dean Hitchcock, namely, that he is a "human engineer." One cannot read many pages without realizing that fact. Dean Hitchcock, with more than due modesty, chronicles the course of his life from boyhood to the present time and parallels with it the development of mechanical, civil, and hydraulic engineering.

His colorful experiences are related in a most readable style. Let me dispel any idea that it is a technical book per se. The technical subject matter is sugar-coated to the degree that the book retains your interest to the last page. That is one reason why I believe every young man contemplating embarking upon an engineering career should be given a copy of it. Another is that it very definitely records the problems of a technical education through the experiences of a student, instructor, professor, and dean of engineering at Cornell and Ohio State Universities, and in parallel with the educational aspects it gives the benefit of Dean Hitchcock's practicing professional engineering experience.

The book confirms the thoughts of most practicing engineers, that college professors and instructors should from time to time leave the campus and affiliate themselves with practical engineering concerns. This practice in Dean Hitchcock's case, undoubtedly, reflected itself in the humane, practical, and democratic execution of his duties as a teacher and dean, and partly accounts for the respect and admiration held for him by the multitude of men who profited from his instruction.

E. G. Bailey, vice-president of the Babcock and Wilcox Company, and Dr. Charles F. Kettering, director of research of General Motors Corporation, were two of Dean Hitchcock's outstanding students at Ohio State. Dr. Kettering has written the introduction of this autobiography and he states in part, "Here is the story of an engineer whose working life has spanned the period of the most rapid development in science and engineering the world has ever seen..... In many of these outstanding developments Dean Hitchcock has had a hand. Important as these contributions are, his most important work has been preparing young engineers to take their places in the world of industry. Many of his students have made large contributions in various fields of engineering and science."

[1] Chief Draftsman, Philadelphia Electric Company, Philadelphia, Pa. Mem. A.S.M.E.

Aerosphere 1939

Aerosphere 1939. Edited by Glenn D. Angle, Aircraft Publications, New York, 1940. Cloth, $8^1/_2 \times 11^1/_2$ in., 1420 pp., illus., $15.

Reviewed by Frederick K. Teichmann[2]

AN encyclopedia of some 1400 pages covering aircraft engines; private, commercial, and military aircraft; vital statistics of the aircraft industry, is now available in one volume entitled "Aerosphere 1939." It is a worthy American competitor to Jane's "All the World Aircraft," published in Great Britain, which has long been the source book for engineers for general information on aircraft engines and aircraft.

Aircraft engines have been dealt with exhaustively both from the engineering and the historical viewpoints. Descriptions cover undoubtedly every aircraft engine, even those which did not pass beyond the design stage, designed in this country or abroad. Specifications and description of distinguishing features of each engine are given in condensed form. Photographs or cross-sectional views of the engines, where available, accompany each description.

The section on aircraft engines covers some 800 pages or more than one half of the volume. Future volumes will probably reduce this section so that descriptions of existing engines only will appear, since no similar presentation of the historical evolution of world's aircraft is given. However, for a first volume, a historical presentation of engine development is both admirable and valuable, and the editor is to be complimented upon his exhaustive research.

In the section comprising some 200 pages, devoted to aircraft, airplanes of 26 countries are described and illustrated. These airplanes fall primarily in the private and commercial categories, although a few military airplanes are described. For those interested, the performance figures given for the airplanes will prove interesting reading and permit ready comparisons. Only existing airplane types have been considered, otherwise, the section devoted to aircraft would have greatly exceeded the section devoted to aircraft engines.

The remaining 400 pages are given over to official world air records, aeronautical government agencies, air-transportation statistics, alphabetical listing of firms and organizations engaged in aircraft activities in the United States and in foreign countries, location of airports, schools engaged in aeronautical education, and miscellaneous information of aeronautical character.

The publishers propose to issue this volume each year. It will be eagerly awaited by all those who wish to obtain aeronautical data quickly.

[2] Associate Professor of Aeronautical Engineering, Daniel Guggenheim School of Aeronautics, College of Engineering, New York University, New York, N. Y. Jun. A.S.M.E.

Books Received in Library

Mechanics of Liquids, an Elementary Text in Hydraulics and Fluid Mechanics. By R. W. Powell. The Macmillan Co., New York, N. Y., 1940. Cloth, $6 \times 9^1/_2$ in., 271 pp., illus., diagrams, charts, tables, $3.50. Believing that the time usually available and the mathematical preparation of most students make it unwise to undertake a thorough presentation of fluid mechanics in an introductory course, the author has confined this work to noncompressible fluids. The result differs very little from the old hydraulics except in point of view and the introduction of recent improvements. The book provides a brief course emphasizing principles and approaching the subject historically.

Modern Electric and Gas Refrigeration. By A. D. Althouse and C. H. Turnquist. Third revised and enlarged edition. Good-

heart-Willcox Co., Chicago, Ill., 1939. Leather, 5 × 8 in., 858 pp., illus., diagrams, charts, tables, $5. This practical textbook for school use and home study covers both domestic and commercial refrigeration. Fundamental physical principles are discussed in the introductory material. Installation and servicing are treated, and there are chapters on refrigerants and air conditioning. Domestic-refrigerator specifications are given, and each chapter has review questions with answers.

MODERN RAILWAY. By J. H. Parmelee. Longmans, Green & Co., New York, N. Y., and London, England, 1940. Cloth, 6 × 9 in., 730 pp., diagrams, charts, tables, maps, $4. This definitive treatment of rail transport in our time covers the historical background, operation problems and processes, and public relations. The wide range of the work takes in the physical plant, human activities, finance, and competitive complications. There are many tables and charts; and digests of Federal railway legislation and Federal railway labor legislation are appended.

NEW TECHNIQUES FOR SUPERVISORS AND FOREMEN. By A. Walton. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1940. Cloth, 6 × 9 in., 233 pp., $2.50. The psychological methods available for the selection, encouragement, and improvement of workers are considered, following a general discussion of the theory behind such methods. Suggestive notes discussing fundamental psychological factors are appended.

PETROLEUM REFINING AND MANUFACTURING PROCESSES. By M. J. Japour. Wetzel Publishing Co., Los Angeles, Calif., 1939. Cloth, 6 × 9½ in., 310 pp., illus., diagrams, charts, tables, $5. This book is intended to present the fundamentals of refinery practice and to supply a general account of the products and their industrial uses. A large part of the book is devoted to lubricants and to recommended specifications and formulas for specific purposes. A chapter is devoted to the significance of tests. The work brings together, in convenient form for reference, a large amount of commercial and practical information.

PHILOSOPHY OF PHYSICAL SCIENCE (Tarner Lectures 1938). By Sir A. Eddington. Cambridge University Press, London, Eng.; The Macmillan Co., New York, N. Y., 1939. Cloth, 6 × 9 in., 230 pp., $2.50. A distinguished scientist presents a companion volume to his previous works. This time he examines the nature of physical knowledge and demonstrates how it is applied to the physical universe. In the two final chapters he presents an outline of a general philosophical outlook which he believes a scientist can accept without inconsistency.

PNEUMOCONIOSIS (Silicosis), the Story of Dusty Lungs, a Preliminary Report. By L. G. Cole and W. G. Cole. John B. Pierce Foundation, New York, N. Y., 1940. Cloth, 8 × 11 in., 100 pp., illus., charts, $1. For several years the Doctors Cole have been investigating this subject under the auspices of the John B. Pierce Foundation. This volume presents the conclusions reached, many of which, the authors say, are not in accord with the accepted ideas. The cause of the disease, its physiological effects, its diagnosis, the social and economic problem that it presents, and the legislative and judicial treatment that should be provided are discussed.

PRAKTISCHE GETRIEBELEHRE, Vol. 2. By K. Rauh. Julius Springer, Berlin, 1939. Cloth and paper, 6 × 9½ in., 298 pp., illus., diagrams, charts, tables; cloth, 29.40 rm; paper, 27.60 rm. A large assortment of mechanisms working on the basic principle of the wedge or inclined plane are discussed from the point of view of the practical designer of machinery. In addition to a general survey of possible mechanisms, the problems of interrelations, transformations, the effects of changed dimensions, and applications are considered in detail. Points brought out in the text are clearly illustrated by many diagrams.

PRIMER OF TIME STUDY. By F. W. Shumard. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1940. Cloth, 6 × 9 in., 519 pp., illus., diagrams, charts, tables, $5. This book was prepared for those who are interested in time-measurement procedure as applied to industrial operations, and is based on the use of the stop watch as a means of establishing standard time and energy values for machines and men. Piecework, premium and group incentive plans are all treated, and there are many practical examples and test questions with answers to increase the working knowledge of the student.

SCIENCE SINCE 1500. (Board of Education, Science Museum.) By H. T. Pledge. His Majesty's Stationery Office, London, England, 1939. Cloth, 6 × 10 in., 357 pp., illus., diagrams, charts, maps, tables, 7s 6d. (Obtainable from British Library of Information, New York, N. Y., $2.15.) A need having been felt for a general survey of the history of science, as a background for the manuals on special scientific subjects published by the Science Museum, Mr. Pledge has prepared this account of the development of mathematics, physics, chemistry, and biology since the end of the fifteenth century. The book is a concise coordinating survey which will be very useful to users of histories of special branches of science. There is a brief, but valuable bibliography.

SILICOSIS. (Studies and Reports, Series F, Industrial Hygiene, No. 17.) Proceedings of the International Conference held in Geneva from Aug. 29 to Sept. 9, 1938. International Labour Office, Geneva, Switzerland; U. S. Branch, 734 Jackson Place, Washington, D. C. Paper, 6 × 9½ in., 223 pp., illus., diagrams, charts, tables, $1.25. The various aspects of the silicosis problem, as discussed at the sittings of the conference, are presented here at length. Topics dealt with include recent advances in knowledge of the pathology of silicosis, the effect of other than siliceous dusts, pulmonary disease caused by dust inhalation, early diagnosis, new methods of dust investigation, determination of disability, dust prevention, personal protection, and specific therapy.

TABLES ANNUELLES INTERNATIONALES DE CONSTANTES ET DONNÉES NUMÉRIQUES. (International Annual Tables of Constants and Numerical Data.) Vol. 11, 1931–1934, Part 1, Sections 1–25. Edited by International Committee of Annual Tables of Constants and Numerical Data. Hermann & Cie, Paris, France; McGraw-Hill Book Co., Inc., New York, N. Y., 1937. Cloth, 7 × 10 in., 519 pp., charts, tables, $10. These tables aim to supply periodically new numerical data, physical, chemical, and technological with comments and a complete bibliography. They are intended for those who make use of quantitative values of the properties of substances and magnitudes that occur in chemical, physical, or technical phenomena and aim to provide a comprehensive digest which will obviate the necessity of searching periodicals. The present volume covers the data upon certain subjects which appeared during the years 1931 to 1934.

TEXAS PETROLEUM REGISTER 1940. Published annually by R. W. Byram & Co., Austin, Texas. Paper, 10 × 12 in., 263 pp., illus., $10. This publication seems well adapted to answer most questions concerning the Texas oil industry and the operators in that field. Of the fourteen sections which comprise the work the two most important ones present an alphabetical listing of company information and an index of oil producers by fields and counties. Also listed are producers of gas, natural-gasoline plants, pipe-line companies, purchasers of gas and crude oil, dealers, refiners, carbon-black plants, licensed engineers, royalty companies and dealers, and service and supply companies.

TEXT-BOOK OF HEAT, Part 1. By H. S. Allen and R. S. Maxwell. Macmillan & Co., London, England; The Macmillan Co., New York, N. Y., 1939. Cloth, 6 × 9 in., 527 pp., diagrams, charts, maps, tables, $3.25. The present part of this two-volume work is mainly descriptive and experimental, and the mathematical treatment has been kept as simple as possible. The development of the science has been traced with full explanation of each step from the earliest notions to modern theories. Brief biographical notes have been included and questions accompany each chapter. The book aims to occupy the place between the elementary textbook and the comprehensive treatise.

TOLERANZEN UND LEHREN. By P. Leinweber. Second edition. Julius Springer, Berlin, Germany, 1940. Paper, 6 × 9 in., 131 pp., illus., diagrams, charts, tables, 7.50 rm. The general subject of tolerances with respect to articles produced with machine tools is discussed, and various factors which enter into the determination of specific cases are explained. All types of gages, their uses, and proper gaging methods are described, and general directions given for design and construction.

TRAINING PROCEDURE. By F. Cushman. John Wiley & Sons, Inc., New York, N. Y., 1940. Cloth, 5 × 7½ in., 230 pp., charts, tables, $2. The author discusses the problems encountered in planning, organizing, operating, and maintaining efficient training programs in industrial, business, and public-service organizations. The discussion is limited to employed personnel, and the principal objective is improvement in the performance of work. Much practical information is given.

VIBRATION OF RAIL AND ROAD VEHICLES. By B. S. Cain. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1940. Cloth, 5½ × 9 in., 258 pp., illus., diagrams, charts, tables, $5. The general principles of vibration are first discussed, mainly in a simple manner but with the use of advanced methods where necessary. Later sections discuss research and test methods, and progress in the design and operation of present equipment for automobiles, streetcars, and railroad vehicles. References are appended.

WRITING THE TECHNICAL REPORT. By J. R. Nelson. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1940. Cloth, 6 × 9½ in., 373 pp., diagrams, tables, $2.50. The technical report is regarded as a structure designed to meet certain definite requirements. Fundamental considerations which bear on the design and composition of a report are reviewed. Specific directions are given for the setup of the report, with several annotated illustrative reports. A systematic procedure is outlined for the critical examination of reports, including some typical cases, and suggestions are made with regard to classroom procedure.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

1940 A.S.M.E. Annual Meeting, New York, N. Y., Dec. 2–5

Most Comprehensive Meeting With 45 Technical Sessions Overtaxes Engineering Building, Causing Change to Hotel Astor for Headquarters

BETTER living and greater industrial progress through engineering, will be the theme for the Sixty-First Annual Meeting of The American Society of Mechanical Engineers to be held in New York City, Dec. 2–5, 1940. Because the facilities and meeting rooms of the Engineering Societies Building, which houses the headquarters of the Society, were found inadequate to take care of 45 simultaneous technical sessions, more than 100 committee meetings, and other affairs, the A.S.M.E. has made arrangements to hold all functions of the 1940 Annual Meeting at the Hotel Astor, located directly on Times Square.

This change of meeting location more than ever symbolizes the vast growth and increased activities of the Society in the last 25 years. The best way to illustrate this is by going back through the years to the Thirty-Sixth Annual Meeting held in New York, Dec. 7–10, 1915. Thirty papers and reports were presented, 14 contributed by committees and seven by Local Sections, which numbered 14 at that time. The six technical sessions were devoted to power plants, machine shops, railroads, textiles, industrial safety, and miscellaneous. There were about 5000 members in the Society, 38 Student Branches, and no Professional Divisions.

Compare these figures to those of the 1940 Annual Meeting. Scheduled for presentation at the 45 technical sessions are more than 100 papers and reports, the majority of which are being contributed through the efforts of the 16 Professional Divisions and one Professional Group. Topics to be covered at the sessions include aeronautics, high-temperature metals, dynamics of vehicles, education and training for the industries, fuel, heat transfer, hydraulic turbines, metal cutting, machine design, work standardization, industrial marketing, mathematical statistics, management, materials handling, seamless-tube manufacture, Diesel engines, petroleum, steam power plants, mechanical-engineering features in the design of electrical apparatus, rubber and plastics, instruments, dust collection, railroad locomotive and passenger-car design, textiles, research, fluid meters, lubrication, and mechanical springs. Today there are approximately 15,000 members, 71 Local Sections, and 119 Student Branches.

Streamlined Program

In keeping with the times, each technical session will be devoted to one specific subject and, in most cases, preprints will be distributed in order to allow more time and opportunity for discussion by interested members specializing in that particular field of mechanical engineering.

Warren H. McBryde, President of the A.S.M.E., will be one of the main speakers who will deliver interesting talks on general and engineering subjects. Outstanding engineers will again be honored with the various awards and honors of the Society. New officers to be elected by the membership during September will be installed during the week of the Meeting.

Inspection trips to points of interest and plants in the metropolitan area will be more varied than ever. Of exceptional interest are the new municipal airport of New York City at North Beach, L. I., Radio City with its Christmas decorations, the new Belt Parkway in Queens and Brooklyn lighted entirely with sodium lights, the Sixth Avenue subway, the Queens-Midtown vehicular tunnel, various public and private housing developments, the *S.S. America*, and the beautiful Bronx-Whitestone Bridge.

Photographic Exhibit

The Fifth Annual Photographic Exhibit, held in conjunction with the 1940 Annual Meeting, will feature photographs covering a variety of technical and nontechnical subjects. All A.S.M.E. members are urged by the Photographic Group of the Metropolitan Section to enter one or more prints.

Library Exhibit

Throughout the Annual Meeting there will be a special exhibit in the Engineering Societies Library, 29 West 39th Street, New York City, covering books and periodicals mentioned in the bibliographies of several of the papers being presented at the meeting. There will also be shown engineering publications issued in the early days of printing, together with some of those of recent times of interest to mechanical engineers. Visitors to the Library will have the privilege of examining and borrowing, under certain rules and regulations, any of its 150,000 volumes, 7000 maps and charts, and 4500 bibliographies.

Student Day

As usual, the Wednesday of the Meeting, Dec. 4, will be designated as Student Day. Student members may take part in the special morning session and in the inspection trips arranged for the morning and afternoon. The special event of Student Day will be the luncheon at which President Warren H. McBryde and the president-elect will give short talks and the winners of student awards will be introduced. Members of Council and other prominent engineers will attend the luncheon.

Employment Service for Engineers

Those members of the A.S.M.E. who are seeking men to fill engineering positions, positions for themselves, or expert advice about their present jobs, will be given an opportunity to talk to a staff member of the Engineering Societies Personnel Service, which maintains offices in New York, Detroit, Chicago, and San Francisco. This personnel man will be available at the Hotel Astor every day of the Annual Meeting for personal conferences. When desired, he will make arrangements for private interviews between prospective employers and applicants. A similar procedure carried out at the Semi-Annual Meeting of the

Herbert Hoover Requests His Name Be Not Written In on A.S.M.E. Presidential Ballot

[*The following telegram is self-explanatory.*]

WARREN H. MC BRYDE
PRESIDENT, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
FINANCIAL CENTER BUILDING
SAN FRANCISCO, CALIF.

I HEAR FROM NEW YORK THAT A CIRCULAR HAS BEEN SENT TO MEMBERS OF THE SOCIETY PROPOSING MY ELECTION AS PRESIDENT. I OF COURSE APPRECIATE THE HONOR OF THE SUGGESTION BUT I HAVE NOT AUTHORIZED THIS AND I WOULD NOT BE ABLE TO SERVE AT THE PRESENT TIME. MOREOVER, I AM INELIGIBLE BEING AN HONORARY AND NOT A REGULAR MEMBER. I HOPE THERE IS SOME WAY YOU CAN COMMUNICATE THIS TO THE MEMBERS BEFORE THE BALLOTING TAKES PLACE. UNDER THESE CIRCUMSTANCES I HOPE THERE WILL BE NO VOTING FOR ME.

HERBERT HOOVER

A.S.M.E. in Milwaukee, June 17-20, 1940, proved very helpful to members, both employers and applicants.

Informal Dance

The Junior Group of the Metropolitan Section has appointed a committee to see what can be done about arranging an Annual Meeting informal dance for Juniors and other members. During the winter meeting of the A.I.M.E. in New York City in February, 1940, such an informal dance with a "name" orchestra, floor show, and refreshments was held at the Hotel Waldorf-Astoria with tickets selling at only one dollar per person. Anyone who is interested in an affair of this type should write immediately to G. L. Lingner or D. E. Zeliff, junior advisory members, A.S.M.E. Committee on Meetings and Program, 29 West 39th Street, New York, N. Y. The next meeting of the Committee at which this matter may be considered will take place on September 13.

Power Show

Although it has no connection with the A.S.M.E. and the 1940 Annual Meeting, the 14th National Exposition of Power and Mechanical Engineering, arranged by the National Exposition Company, will take place at Grand Central Palace, New York City, Dec. 2-7, 1940. According to advance reports, nearly 250 leading concerns have engaged exhibit space making the show one of the largest since 1930.

Col. L. B. Lent Is New Secretary of A.E.C.

At the meeting of the executive committee of American Engineering Council on July 29, the engagement of Colonel L. B. Lent, consulting engineer, as executive secretary of A.E.C. was authorized. He assumes the duties of F. M. Feiker, who resigned several months ago to accept a position as dean of engineering at George Washington University.

Colonel Lent is a native of Brewster, N. Y., and a graduate of Stevens Institute of Technology, Hoboken, N. J. After five years as associate editor of the technical magazine *Power* his studies of gas-engine development led to an association with the Riverside Engine Company, Oil City, Pa. The installation by this firm of several large engines for the Ford Motor Company resulted in his employment by Mr. Ford as assistant chief engineer of construction and maintenance. Entering the Army during the World War, he was assigned to the development of airplane engines at the Curtiss plant in Buffalo, N. Y., subsequently being transferred to Langley Field, Va., as engineer officer and later to Camp Vail, N. J., as commanding officer of Air Service Troops at that field. He subsequently had command at Brindley Field and Roosevelt Field.

After the War he became superintendent of the U. S. Air Mail Service and played a prominent part in the development of the early routes connecting Chicago with St. Louis, Minneapolis, and San Francisco and organized the first transcontinental service from New York to San Francisco. Colonel Lent entered trade association work as chief engineer of the Common Brick Manufacturers' Association of America. He later became executive officer of the Scientific Apparatus Makers Association, writing and administering the NRA code for the 500 members of this industry. He was then made president of the Panoptik Company, which administered a patent licensing plan in the field of optical products.

More recently, Colonel Lent has been a consultant in the aviation field, especially as engineer to the Aeronautical Development Commission of the State of Connecticut.

How the A.S.M.E. Elects Its Officers

During the latter part of August ballots were mailed to all voting A.S.M.E. members for the purpose of electing officers of the Society—three managers to serve for three years, three vice-presidents to serve for two years, and the president who serves for one year. Although the manner in which such officers are nominated and elected is clearly set forth in the Constitution, By-Laws, and Rules of the Society, a review of this procedure serves the useful purpose of emphasizing the really democratic process followed.

Nominating Committee Named by Local Section Groups

Officers are selected by a Nominating Committee whose members are chosen by the Local Sections in such a manner that all areas of the country are represented. Between October 1 and the Annual Meeting in December each one of the eight groups of Local Sections nominates one member and an alternate to serve on this Committee. The names thus selected are acted upon by the Conference of Sections Group Representatives during the Annual Meeting, at which time the Chairman of the Committee on Local Sections, or the committee's senior member, presides. At the business session of the same Annual Meeting the personnel of the Nominating Committee is announced by the chairman of the Committee on Local Sections and the members and alternates are declared elected.

As soon as practicable—usually during the week of the Annual Meeting—the Nominating Committee meets for organization. The chairman and secretary of the Nominating Committee of the previous year serve the new committee as advisory member and alternate, respectively, without vote. At the organization meeting the committee selects its chairman and secretary and issues a statement for publication in the February issue of Mechanical Engineering in which it announces the names of its members and officers, solicits proposals of candidates for officers from members, and describes briefly the qualifications sought for in the candidates to be considered.

Procedure of Nominating Committee

The Nominating Committee issues a form upon which names may be proposed and information on qualifications presented. Enough copies to provide one each for every member of the committee (eight) are asked for in connection with every name proposed. These are sent to the secretary of the committee who distributes them to his colleagues. It is the secretary's duty to carry on all correspondence. None of this passes through the Society headquarters. In carrying on this work the members of the Nominating Committee address their letters to the secretary and send copies to all other members, and each member keeps a complete up-to-date file of all proposals and correspondence which can be turned over to his alternate in case of necessity. He also keeps his alternate currently informed on committee business so that the alternate can represent him intelligently on short notice.

The Nominating Committee holds open meetings at the Semi-Annual Meeting of the Society. At these open meetings every Society member may speak on behalf of candidates under consideration or propose additional names to the committee. When the Nominating Committee, following the open meeting, comes to its decisions respecting candidates it proposes to nominate, it secures in writing, or by telegram, from each candidate his acceptance to serve in the office for which he is to be nominated. Until all of these written acceptances are in the committee's hands, no announcement is made. When all are in order, the list of nominees is handed to the Secretary of the Society, with the written acceptances, and the names are made public by him. The Secretary is then required to publish the report of the Nominating Committee and biographies of the nominees in Mechanical Engineering.

Election Is by Letter Ballot

Letter ballots are mailed to all members of the Society on or before the third Thursday in August. As these ballots are returned in properly sealed and signed envelopes to headquarters, the Secretary checks signatures and competence of voting members. Balloting closes at 10:00 a.m. on the fourth Tuesday in September and all ballots received after that time are thrown out. The ballots are canvassed by three tellers appointed by the president and the rules require that candidates be informed by the secretary of their election by October 1. At the business session of the Annual Meeting the presiding officer declares the successful candidates elected. The new officers' terms of service begin immediately after the adjournment of the Annual Meeting.

Special Nominating Committees May Be Formed

Provision is also made in the Constitution and By-Laws for the setting up of special nominating committees which may be organized by any group of one per cent of the members certifying to the Secretary their joint intention to organize such a committee. Names of the nominees of a special nominating committee must be in the hands of the Secretary by the first Tuesday in August and must be accompanied by written consent of each nominee. The names of such nominees are printed on the ballot with those of the nominees of the regular Nominating Committee, but in a separate list under the names of the special committee that has proposed them.

A.S.M.E. Machine Shop Practice Division Schedules Meetings on Shells Manufacture

Special Meetings to Be Held in Pittsburgh, Sept. 11, and in Cincinnati, Oct. 16–17

THE Ordnance Department of the U. S. Army has accepted the offer of the Machine Shop Practice and Metals Engineering Divisions of The American Society of Mechanical Engineers to arrange a series of meetings of engineers and manufacturing executives for an exchange of experience in the methods for quantity production of shells for the Army. The American Institute of Mining and Metallurgical Engineers is cooperating in the problems of heat treating.

The nation's leading manufacturers, who have expressed a willingness to accept contracts for shell manufacture, are being invited by the Divisions to send representatives to the first of these meetings, scheduled to be held at the William Penn Hotel, Pittsburgh, Pa., Sept. 11. A second meeting is already being arranged for Oct. 16 and 17, at the Gibson Hotel, Cincinnati, Ohio.

Prof. Frank Macconochie, department of mechanical engineering, University of Virginia, has been appointed by President Warren H. McBryde of the Society to aid the sponsoring Divisions in arranging the meetings.

In the preliminary meeting at Pittsburgh on Sept. 11, discussions on forging and machining of shells will be presented. From these discussions it is planned to secure further formal papers for the Cincinnati meeting in October. It is hoped that the resulting publications will provide a useful handbook for engineers and shell manufacturers. Further information may be obtained from Ernest Hartford, assistant secretary of the A.S.M.E., 29 West 39th Street, New York, N. Y.

A.S.M.E. Committee on Admissions Clarifies Fellow Grade

ALTHOUGH five years have elapsed since the Fellow grade of membership in The American Society of Mechanical Engineers was established by constitutional amendment in 1935, differences of opinion about the manner in which members should be elected Fellows and misunderstanding on the qualification entitling members to election still exist.

Member Ballot Approved Fellow Grade

The Fellow grade was first proposed in 1934 by the Committee on Policies and Budget which made an exhaustive study of A.S.M.E. affairs during the depths of the depression. Great care was exercised in submitting the proposal to free and frequent discussion. In July, 1934, the Council approved the new grade in principle, and submitted the proposal to group conferences of local sections held in the fall of 1934 with favorable results. Specifications covering the Fellow grade were approved by the sections delegates in New York in December, 1934, after which constitutional amendments were prepared, discussed at length at the Semi-Annual Meeting in Cincinnati, July 17–21, 1935 (see MECHANICAL ENGINEERING, August, 1935, pp. 511 and 532), and sent to the members for letter ballot on August 15, 1935. Specifications covering the Fellow grade were printed on the ballot. As a result of a favorable vote, the Fellow grade was established by constitutional amendment. Establishment of the Fellow grade was therefore the result of deliberative discussion and legal procedure.

What a Fellow Is

The present Constitution defines a Fellow as "an engineer who shall have distinct engineering attainments" (C4 Sec. 3), and the present By-Laws direct that a Member desiring to become a Fellow "shall make application to the Council on an approved form" (B4 Par. 1). This means that in order to become a Fellow a Member applies for promotion to an upper grade just as he does when he passes from Junior to Member grade. From time to time it has been proposed that the Fellow grade be made an "honor" grade to which a Member would be elected following nomination by certain proposers or a committee charged with such a duty. This is not the concept of the Fellow grade as set forth in the Constitution. Although the Fellow grade is a recognition of distinction, it is not an honorary grade of membership. A Member applies for promotion to it on the basis of his engineering attainments; he is not nominated to it with the object of conferring an honor upon him.

Interpretation of "Distinct Engineering Attainment"

A frequent source of misunderstanding lies in the meaning of the expression "distinct engineering attainment." To some persons the word "distinct" means "separate" or something that is readily distinguishable. To others it means "noteworthy," "unusual," or "extraordinary." All of these meanings are correct. Hence "distinct attainment" is something worthy of special recognition because it is definite and is not likely to be found in a man of ordinary or mediocre ability.

This confusion of meaning makes desirable an interpretation, a definition, a specification, or an illustration. Indeed, without an adequate definition of "distinct engineering attainments," a Member does not know whether he is entitled to apply for promotion to the Fellow grade and the Committee on Admissions would have no "yardstick" to use in passing on the Member's application.

Specifications of Fellow Grade Used by Committee on Admissions

At present the Committee on Admissions has such a yardstick in the form of a report, dated May 17, 1937, prepared at the request of the Council by a special committee that consisted of Messrs. A. A. Potter, Alfred Iddles, and James Todd. In this report, entitled "Interpretation of Qualifications for the Fellow Grade," the phrase, "engineer of distinct engineering attainments" was interpreted as including:

An engineer who has been responsible for design or construction of major significance; usually several projects, such as a line of tools.

An engineer who has rendered special service to the government.

A professorship in an institution would not ordinarily be considered a distinct service unless accompanied by a reputation as an engineer, or by evidence that the candidate is an author or authority in some special branch.

Authorship: The requirement that the publication should have superior merit is probably the ruling consideration. The acceptance by the Society of a considerable number of papers over a period of years for publication in the Transactions would certainly tend to build up a reputation for distinct engineering attainment but the quality would be the most important consideration.

Contributions to the standing of the engineer or to the enhancement of the engineering profession should certainly be given consideration.

The Fellow grade should cover the professional man of full stature rather than simply a strict technician, recognizing, of course, the necessity for technical attainment.

In general, those advanced to the grade of Fellow should have acquired *distinction* in one or more branches and should be recognized as outstanding authorities in their particular specialty. Care should be taken not to award too many Fellow memberships, as the award of this grade should imply recognition of a professional attainment of a high order.

Misunderstanding Persists

Notwithstanding this "interpretation," which is used by the Committee on Admissions, and notwithstanding the fact that the By-Laws still direct that application for this grade must be made by the member himself on an approved form, misunderstanding persists. Many members still do not understand that they must apply personally for promotion to this grade and will not be nominated for it by others as though it were an honorary grade, and they are not familiar with the "Interpretation of Qualifications" just quoted.

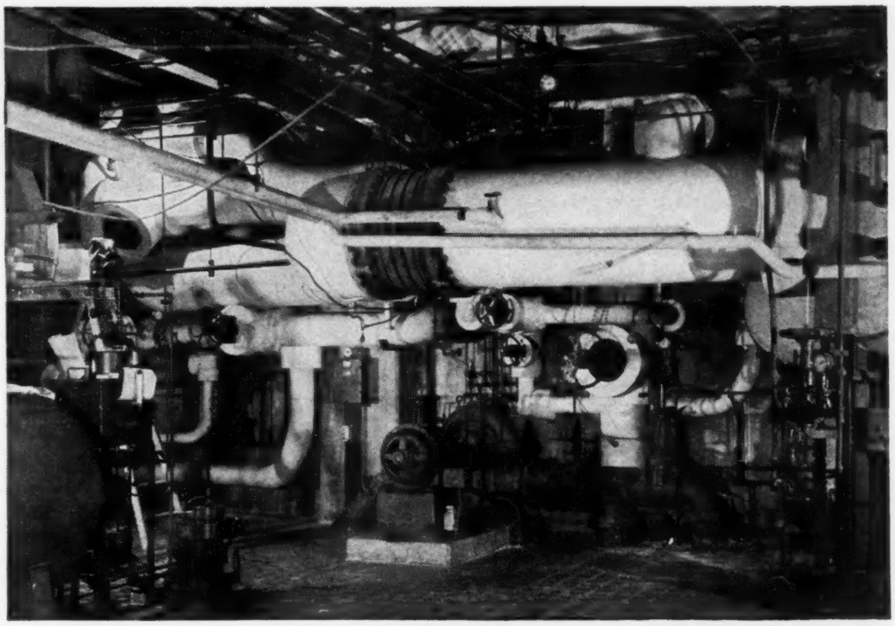
In an attempt to remove misunderstandings of members with respect to the Fellow grade, the Council of The American Society of Mechanical Engineers, at its meeting at Milwaukee, June 16–17, 1940, asked the Committee on Admissions "to review and revise the specifications for the Fellow grade and to consult the Local Sections in so doing."

Procedure of Committee on Admissions

The Committee on Admissions therefore reports that it interprets the purpose of the

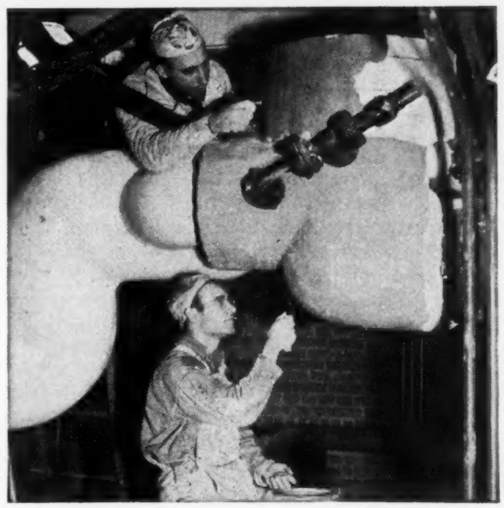
(*A.S.M.E. News continued on page 696*)

DOES YOUR INSULATION INVESTMENT PAY A *FULL* RETURN?



On Furnaces where insulation is required to resist temperatures up to 1900° F., J-M Superex is widely recognized as the most efficient block insulation available today. Hundreds of installations under all types of operating conditions prove its long life and low maintenance.

For Temperatures Up To 600° F., you save by using J-M 85% Magnesia. For years the standard material for insulating power-plant equipment and steam lines, it combines light weight with permanently high insulating efficiency.



On Superheated Steam Lines, J-M Superex Combination Insulation effectively guards against costly heat waste. Built up of an inner layer of Superex and an outer layer of 85% Magnesia, this combination assures maximum heat resistance and insulating efficiency.

HOW much money you spend on fuel depends to a large extent on the answers to these two questions:

Are you using the *correct insulating materials?*

Are they applied in the *correct thicknesses?*

To assure every saving possible with insulation, it will pay you to call in a J-M Insulation Engineer. Let him study your requirements . . . his specialized technical training and experience will help you trace down and correct sources of heat waste that may otherwise go unnoticed.

From the complete line of J-M Insulations, he can recommend exactly the *material* you need for greatest efficiency . . . exactly the *thickness* you need for maximum returns.

For full details on this helpful service and facts about the complete line of J-M Industrial Insulations, write to Johns-Manville, 22 East 40th Street, New York, N. Y.

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Constitution and By-Laws as that of establishing a grade of membership—the Fellow grade—that recognizes distinction in engineering attainments as a primary qualification, promotion into which grade shall be made only by personal application on an approved form. In judging the qualifications of applicants for promotion to the Fellow grade the Committee follows the "interpretation" of the special committee of Messrs. Potter, Iddles, and Todd already quoted. It gives painstaking scrutiny to all applications for promotion to the Fellow grade. It makes an extensive investigation of each applicant's record. In its decisions it is governed by evidence of distinguished engineering achievement in invention, design, construction, research, and government service. The names of members recommended for promotion to the Fellow grade are presented to the Council in session, are voted on by those present, and are submitted by letter ballot to Council members not present at that meeting. In accordance with the By-Laws, two negative votes of Council members defeat an election to Fellow grade.

No Change in Fellow Grade Recommended

The Committee on Admissions further reports its opinion that the Fellow grade has not yet had a fair trial either to prove its worth or to prove that it should be modified.

The Committee recommends that no change in respect to the Fellow grade be made in the Constitution and By-Laws at this time. Frequent change of membership grades denotes instability.

To make the specifications for promotion to this grade clearer by interpretation so that the Fellow may be understood by all to be an engineer of distinction or an engineer of distinguished engineering attainments seems to be the first step. If that is not satisfactory after a reasonable trial, then a change is justified.

It is hoped that the foregoing statement will provide the means of clarifying understanding of the Fellow grade.

Men and Positions Available

Send inquiries to New York Office of Engineering Societies Personnel Service, Inc.

29 W. 39th St. New York, N. Y.	**211 West Wacker Drive Chicago, Ill.**	**57 Post Street San Francisco, Calif.**	**Hotel Statler Detroit, Mich.**

MEN AVAILABLE[1]

HEAT EXCHANGE ENGINEER, 32, N. J. license. Thirteen and one-half years in design, manufacture, selling, and application of heat-transfer equipment for marine service. Knows rules of U.S.B.M.I.N., and A.B.S., and U.S. Maritime Commission. Me-511.

MANAGER OR SUPERINTENDENT, 47, married. Broad experience in installation, maintenance, and operation of telegraph and telephone (wire and wireless), signaling, and control equipment. Superintendent I/C transoceanic communication. European, Oriental, and Canadian experience. Available immediately, location, immaterial. Me-512.

MECHANICAL ENGINEER with experience on electric-transmission-line construction, high-pressure piping installation, and drafting and gasoline plant layout. Married, 18 months out of college. Prefer west central location. Me-513-535-Chicago.

MANUFACTURING PLANT MANAGER, chief engineer, 38, graduate. Advanced business-administration studies; organizer and coordinator with background of plant and industrial engineering in process and assembly industries. Now employed. Me-514.

EXECUTIVE ENGINEER, 30 years in responsible charge wide variety mechanical engineering, specializing in materials-handling equipment, heavy machinery, all kinds gates, cranes, and accessories for hydroelectric projects. Seeks new connection. Me-515.

GRADUATE MECHANICAL ENGINEER, 26, single. Four years' general experience, one year with metal-container manufacturing company; familiar with costs, spoilage, production, and efficiency control, personnel administration, correspondence, construction supervision. Me-516.

[1] All men listed hold some form of A.S.M.E. membership. Where no city is shown after name, man may be reached through the New York office.

RESEARCH ENGINEER OR METALLURGIST, 32, married. Wide experience in steel-fabricating industry including design, development, and production engineering. Familiar with all aspects of arc and Unionmelt welding. Me-517.

ASSISTANT PRODUCTION ENGINEER, single, honor graduate. Two years as machine-shop apprentice, fifteen months as works manager's assistant in production of internal-combustion engines and gears. Fast draftsman, good organizer. Me-518.

MANUFACTURING PLANT MANAGER OR SUPERINTENDENT, organizer, coordinator, thoroughly conversant all plant activities, controls for materials, production, and costs. Background of industrial engineering experiences in mechanical- and electrical-products plants and in process industries. Me-519.

MECHANICAL AND ORDNANCE ENGINEER, experienced in design, construction, inspection, and testing of machine, automatic, semiautomatic, and rapid-fire guns, sights, mounts, field carriages, ammunition, special machinery, tools, jigs, fixtures for manufacture. Me-520.

MECHANICAL, registered professional engineer; '35 Georgia Tech, Co-op graduate. One year drafting. Two years supervising erection, planning, and making erection drawings of semiheavy machinery. Two years designing semiheavy machinery. Me-521.

MECHANICAL GRADUATE; 27; N. C. State, 1936; single. Experience in power-plant operation, construction, and maintenance. Desires steam or Diesel plant operation and maintenance. Will go to foreign country. Now employed. Me-522.

MAINTENANCE ENGINEER, A.S.M.E.; University graduate; 40. Now employed. Fifteen years' varied experience including institutional maintenance and development, general construction, and mechanical-electrical design. Mechanically inclined, practical, cooperative supervisor. Interested in position offering economic, professional advancement. Me-523.

ORDNANCE MANUFACTURING EXECUTIVE, large-scale production of 5 to 16-in. shells, submarine torpedoes, launching tubes, and mines. Immediately available for organization or direction of production. Me-524.

MECHANICAL ENGINEER, 35. Thirteen years' experience covering construction, chemical-plant operation and maintenance, design, manufacturing, sales, valves, metering, and control apparatus. Now employed, California. Desires contact with interests requiring able conscientious man. Me-525.

MECHANICAL ENGINEER, desires position in design, development, experimental research, or teaching on combustion engines or machine design. Special qualifications: Inclination to research, analytical ability, inventiveness, preparation of comprehensive reports or technical papers. $350 per month least considered. Me-526-586-Chicago.

POSITIONS AVAILABLE

[NOTE: *Unemployed Michigan members are urged to register immediately with the Detroit office which has many mechanical-engineering positions available.*]

DESIGNING DRAFTSMEN, thoroughly experienced in power-plant work involving high-pressure boilers, turboblowers, and turbogenerators. Experience should be preferably with structural steel and concrete; high and low-pressure piping; general layout work; boiler, turbine, and auxiliaries installation. Location, Pennsylvania. Y-6076.

SALES MANAGER, 25–35, mechanical engineering or petroleum graduate, with at least 5 years' experience in sales, preferably in connection with petroleum industry. Should have good sales direction ability to head group selling oil-well specialties. Salary, $3000 year and expenses. Middle West. Y-6081C.

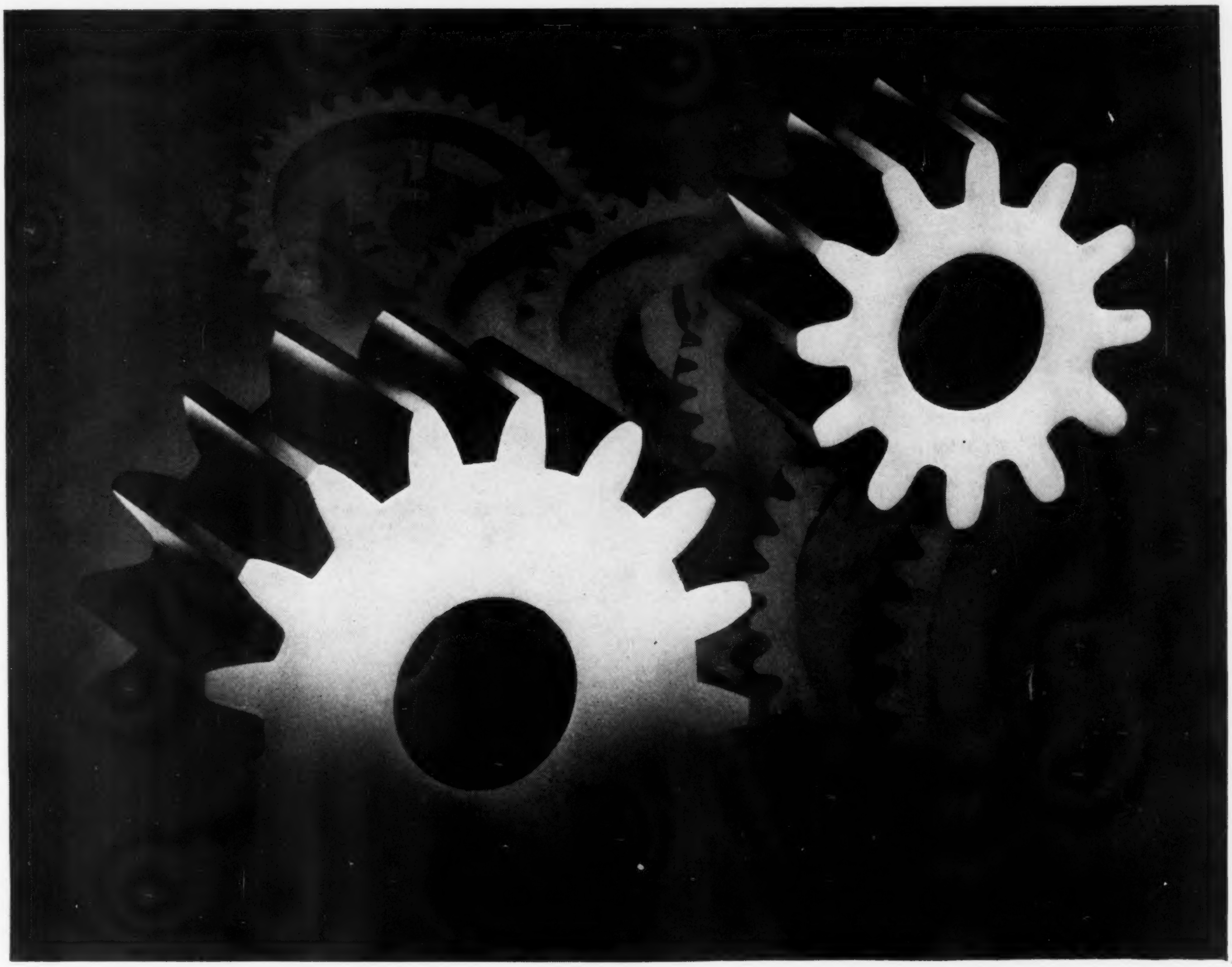
RECENT GRADUATE MECHANICAL ENGINEERS, with from 1 to 3 years' experience in industrial engineering. Salary, $175–$225 a month. Location, Pennsylvania. Y-6085.

MACHINE AND TOOL DESIGNERS, technical college graduates, with at least 10 years' experience. Must be American citizens. Salary, $50–$60 a week. New Jersey. Y-6086.

GRADUATE MECHANICAL ENGINEER with well-rounded shop experience and natural gift for machine design. Applicant will head production-engineering work. Must know problems and be able to direct tooling up of shop; must know methods of accomplishing specific work as well as production line; must be familiar with designing of tools, jigs, fixtures. Location, Pennsylvania. Y-6088.

GRADUATE MECHANICAL ENGINEER, with well-rounded shop experience, and natural gift

(*A.S.M.E. News continued on page 698*)



for design. Applicant will work immediately under tool supervisor and be responsible for draftsmen and engineers engaged in tool and fixture design. Pennsylvania. Y-6089.

DEVELOPMENT ENGINEER to supervise force of draftsmen, modelmakers, and oversee the design tools manufactured in toolroom. Applicant must be capable of developing new ideas on own initiative and should be more interested in development part of manufacturing program than in actual manufacturing. Location, New England. Y-6112.

PAINT ENGINEER, about 30–35, preferably graduate chemical engineer, for special corrosion problems. Would analyze present paint problems, appraise results, and formulate program of initial and maintenance painting for ships. Salary, $250–$300 a month. Location, East. Y-6117.

ASSISTANT EXPERIMENTAL ENGINEER, 35–50, graduate of recognized college or university. Applicant should have 3 years' chassis experience including independent wheel suspension, steering geometry, Hotchkiss and torque-tube drive; should also have 5 years' motor-layout experience, including crankshaft balancing, work with different types of motors, and air-cooled motors of two-cylinder opposed type. Experience should have been with recognized automotive manufacturer. Should be able to do production engineering and act as liaison man between engineering and production departments. Ohio. Y-6134D.

STEAM POWER PLANT ENGINEER, 40–45, capable of directing industrial power-plant project. Must have ability to supervise designers. Location, South. Salary, $4000–$5000 year. Y-6140.

TIME STUDY ENGINEER, young, preferably one with some chemical-plant experience. Should be graduate engineer. Salary, $200–$250 a month. Location, New Jersey. Y-6141.

MECHANICAL ENGINEER, 35–40, as assistant superintendent of manufacturing plant. Wire or wire-rope experience desirable. Salary, up to $4000 year. New England. Y-6158.

GRADUATE MECHANICAL ENGINEERS, 25–35, with factory experience in production plants and in tool design and shop methods, shop cost estimating, and similar work. Aircraft-manufacturing experience is almost indispensable; closely related experience in sheet-metal manufacturing beneficial. Apply by letter. Location, Middle West. Y-6167C.

TOOL AND DIE DESIGNERS, 25–45, mechanical-engineering graduates preferred. Must be good draftsmen experienced in design of jigs, fixtures, medium-size die equipment, and miscellaneous tools; preferably men who have handled this type of work in job shops. Must have good appearance and personality and be capable of working with others, keeping in touch with department heads and following through on program. Work is entirely on the board. Salary, $275–$300 month. Ohio. Y-6173D.

DESIGNER, up to 50, mechanical engineer, to work on precision instruments, range finders, aero cameras. Must be American born. Salary, $55–$70 a week. Location, New York metropolitan area. Y-6178.

DESIGN AND DEVELOPMENT ENGINEER with recent experience in design and detail of motors, generators, and other electrical equipment. Aircraft or automotive background desirable. Salary, $60–$70 week. Location, East. Y-6187.

SALES ENGINEER, graduate mechanical engineer, with several years' experience in instrument field. Applicant will work in field, calling on established customers to maintain contacts and on prospective new customers. Excellent opportunity for advancement. Considerable traveling. Salary open. Apply by letter stating age, experience, and other pertinent details. Headquarters, Pennsylvania. Y-6194.

GRADUATE ENGINEER, young, to act as assistant to chief engineer in laboratory of designing and development. Applicant should have some experience and knowledge in manufacturing of small panel-mount electrical measuring instruments. Apply by letter stating experience, education, age, and salary expected. Opportunity for advancement. Location, New England. Y-6219.

SUPERINTENDENT, 35–50, with executive ability for company manufacturing building material and miscellaneous hardware. Salary open. Location, New England. Y-6234.

ENGINEER, young, with experience in drawing decorative designs in small hardware products. Inventive ability to develop small sheet-metal articles of hardware also desirable. Apply by letter stating experience and salary expected. Location, New England. Y-6241.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after September 25, 1940, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references.

Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

BAKER, LOUIS R., Swanton, Ohio
BOYER, GLENN C., Kansas City, Mo.
CAMERON, JOHN R., East Orange, N. J.
CANTLEY, WILLIAM I., Chicago, Ill.
CLUVERIUS, WAT T., Worcester, Mass.
CRAGG, R. J., Cincinnati, Ohio (Rt.)
DAWSON, WILLIAM N., Chicago, Ill.
DODKIN, OSWALD H., Sao Paulo, Brazil, S. A.
GIACCIO, FRANK J., Corona, Queens, L. I., N. Y.
HANKINS, CYRUS, Washington, D. C. (Rt.)
HARRELL, CLAUDE L., East St. Louis, Ill.
LYNCH, DANIEL G., San Francisco, Calif.
MCWHORTER, HENRY L., Des Moines, Ia.
MALIN, CHESTER G., San Francisco, Calif.
MINER, ANSON W., Waterbury, Conn.
MOSLANDER, KENNETH D., Cleveland, Ohio
PANELO, PEDRO D., Sacramento, Calif.
PATTISON, RONALD, Cadishead, Nr. Manchester, England
ROGERS, FRED S., Ithaca, N. Y.
RUSSELL, ARTHUR O., Fredericksburg, Va. (Rt.)
SJOLIN, NILS, Brooklyn, N. Y.
TISHLARICH, OTTMAR M., Bellevue, Pittsburgh, Pa.
THORNE, RAYMOND B., Chattanooga, Tenn.
TULLOSS, JOSEPH C., Washington, D. C. (Rt.)
VALOIS, ALEX. A., Watertown, Mass.
VAN SAUN, WILLAR G., Janesville, Wis.
WALL, TURNER S., Laughman, Fla.
WELLS, ROBERT F., Orillia, Ont.
WITHINGTON, TOM V., Philadelphia, Pa.

CHANGE OF GRADING

Transfers to Member

DAM, CYRUS K., San Francisco, Calif.
SHANNON, FRANCIS P., Louisville, Ky.
STEPAN, THEODORE E., Vicksburg, Miss.

A.S.M.E. Transactions for August, 1940

THE August, 1940, issue of the Transactions of the A.S.M.E. contains the following papers:

- Automatic Integrating Pressure-Traverse Recorder for Study of Flow Phenomena in Steam-Turbine Nozzles and Buckets, by H. Kraft and T. M. Berry
- An Investigation of Energy Losses in Steam-Turbine Elements by Impact-Traverse Static Test With Air at Subacoustic Velocities, by W. R. New
- Photoelastic Analysis of Stresses in a Steam-Turbine Blade Root, by J. J. Ryan and J. T. Rettaliata
- Permanence of the Physical Properties of Plastics, by J. Delmonte
- Laminar-Flow Heat-Transfer Coefficients for Ducts, by R. H. Norris and D. D. Streid
- Performance Characteristics of Dye Jigs, by W. B Heinz

Necrology

THE deaths of the following members have recently been reported to the Society:

CHAMBERLAIN, PAUL M., May 27, 1940
CORNELIUS, HENRY R., July 24, 1940
FRETSCHMIDT, CURT, February 19, 1940
KNOWLTON, FREDERIC K., December, 1939
LAROCCA, JOHN A., July 17, 1940
RUSSELL, WALTER B., July 13, 1940
SABIN, ALVAH H., July 11, 1940
SWANBERG, F. L., February 12, 1940